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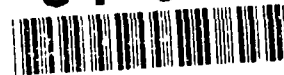
Judgments of Probability and Relative Importance in a Military Decision Scenario: The Influence of Subjective and Objective Variations in Causal Factors

Robert M. Hamm
U.S. Army Research Institute

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For this report, researchers used hypothetical battle decision situations to study
ilitary officers' judgment of probability and relative importance. For the study, 222
orrespondent and 72 resident students of the Command and General Staff College read a
escription of one or two military situations, assessed the probability of mission success,
nd judged the relative importance of several situational factors. Probability judgments
ere insensitive to variations in the important factor of enemy strength, yet in one problem
hey responded to irrelevant variations in the mood of the presentation of the situation.
elative importance judgments were, on the whole, "global," that is, stable over situational
hanges. College students' judgments were similar to military officers' except that college
tudents thought the missions had greater chance of success.

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Technical Report 931

Judgments of Probability and Relative Importance in a Military Decision Scenario: The Influence of Subjective and Objective Variations in Causal Factors

Robert M. Hamm
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This study applies judgment and decision making research techniques to military officers' understanding of factors in the battlefield pertinent to the success of planned courses of action. The need for judgments of probability and of relative importance is widespread in operational contexts. The work was carried out in the Fort Leavenworth Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences Systems Research Laboratory, whose mission is to improve the efficiency, accuracy, and timeliness of command and control (C^2). The work was performed under the auspices of the National Research Council Associateship program.

EDGAR M. JOHNSON
Technical Director

ACKNOWLEDGMENT

JUDGMENTS OF PROBABILITY AND RELATIVE IMPORTANCE IN A MILITARY
DECISION SCENARIO: THE INFLUENCE OF SUBJECTIVE AND OBJECTIVE
VARIATIONS IN CAUSAL FACTORS

EXECUTIVE SUMMARY

Requirement:

    A key function in command and control is monitoring the
uncertain and changing battlefield so that one may act
appropriately. Communication about the battlefield situation
uses expressions of probability to discuss uncertainty, and
expressions of relative importance to direct attention to factors
that potentially play key roles in determining the outcome of
battle. In order to be meaningful, these communications must
have certain characteristics. For probability, these include
accuracy, coherence, and independence from irrelevant influences.
For relative importance judgments, a desirable characteristic is
that judgments be global or general, rather than local cr
particular. A study was done to test these features of
communication about probability and relative importance.

Procedure:

    Subjects were 294 students of the Command and General Staff
College, and for comparison 154 undergraduate college students.
Each read a description in which a commander had to respond to a
situation. Two problems were used, one about a response to a
crashed helicopter, the other about an attack across a river.
For each problem, the subject estimated the mission's probability
of success and the relative importance of eight situational
factors.

    The situation descriptions were varied between subjects to
manipulate the probability of mission success. In one set of
conditions the strength of the enemy was varied. For example, in
the river problem the enemy was said to be at 50%, 70%, or 90%
strength. In another set of conditions, the mood of the
presentation was varied by changing the description of the
situation and the characters' feelings and remarks without
changing the facts of the situation.

Findings:

Subjects' judgments of probability of mission success were not sensitive to the enemy strength. However, on one of the problems they were sensitive to variations in the subjective factors. While the most direct evidence indicated that subjects make global relative importance judgments, indirect evidence (a "halo effect") showed local effects, that is, that the relative importance of factors was influenced by the particular situation rather than being constant across variations in the situation. College students' judgments were similar to military officers' except that the students reported greater probabilities of success.

Utilization of Findings:

The results suggest that there is a need to train Army officers to use probabilities better in operational contexts. For the most part, relative importance measures are stable across changes in the situation, indicating that they may be useful for general analysis of command and control. In situations where local judgments of relative importance are appropriate, it may be better to communicate in terms of changes in probability than to use a general vocabulary of importance.

JUDGMENTS OF PROBABILITY AND RELATIVE IMPORTANCE IN A MILITARY DECISION SCENARIO: THE INFLUENCE OF SUBJECTIVE AND OBJECTIVE VARIATIONS IN CAUSAL FACTORS

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JUDGMENTS OF PROBABILITY AND RELATIVE IMPORTANCE IN A MILITARY DECISION SCENARIO: THE INFLUENCE OF SUBJECTIVE AND OBJECTIVE VARIATIONS IN CAUSAL FACTORS

Introduction

Monitoring of uncertain and changing situations is a key function of command and control (Crumley, 1989; Olmstead, Christensen, and Lackey, 1973). Because much battlefield knowledge can hot be certain, a way of gauging uncertainty is required. And because the point of command is to direct action toward a goal, estimation of the relative importance of different factors in the situation that influence the attainment of the goal is also needed. "An active leader will keep abreast of the situation at all times and weight pertinent factors at any given time when action on his part is required" (Major General John B. Coulder, 1948; quoted by Campbell and McKinney, 1990, p 57). Reliable communication of these assessments of uncertainty and importance is necessary.

Uncertainty or degree of belief may be measured using expressions of probability. A numerical measure of probability has strong advantages over alternative measures (Hogarth, 1987). But people's subjective numerical probabilities are not always accurate. Poor calibration has frequently been demonstrated when people assess their degree of belief in the accuracy of their knowledge of simple facts (Lichtenstein, Fischhoff, and Phillips, 1982), but also with judgments concerning complex situations about which the judge has extensive knowledge (Poses, Bekes, Copare, and Scott, 1990; Tape and Wigton, 1989). It has been demonstrated, however, that those with much experience assessing probabilities of weather (Murphy and Winkler, 1977) or patient mortality in an intensive care unit (McClish and Powell, 1989) are quite accurate. Perhaps unconfident in their numerical expressions of probability, people often prefer verbal expressions (Wallsten, Budescu, Rapoport, Zwick, and Forsyth, 1986) or avoid measuring it at all (Kuipers, Moskowitz, and Kassirer, 1988). Given the potential utility of subjective probability assessments in military operations, and the uneven quality of people's probability judgments in other contexts, it is of interest to know how well military officers can judge the numerical probabilities of complex battlefield events.

Judgments of relative importance. The definition of a measure of relative importance depends on the context in which it is used (Hamm, 1990c). The prediction context is especially pertinent to command and control: in the causal structure of a battlefield, some factors are more important in controlling the outcome of the battle than others. One person's judgments of relative importance can guide others in focusing attention or effort when managing (or coping with) the battle. A small number of researchers have investigated relative importance judgments in the prediction

context (Fischhoff, 1975; Hamm, 1990a, 1990d; Wasserman, Lempert, and Hastie, 1990). In related work involving judgments of the importance of story elements (sentences or phrases) for the meaning of the story (Trabasso and Sperry, 1985), and of the importance of evidence elements for a decision about guilt or innocence (Pennington and Hastie, 1988), the element's importance has proven to be related to its causal role in the story. This suggests that people will find it natural to judge relative importance in a predictive context.

Much past work on subjective judgments of relative importance has focussed on the preference context (e.g., what factors in a battle outcome are more important in determining how good the outcome is; see for example Anderson and Zalinski, 1988; Goldstein, in press; Reilly and Doherty, 1989; Schmitt and Levine, 1977). Issues raised in the preference context are pertinent to the judgment of relative importance in the prediction context.

One issue is whether people make <u>local</u> or <u>global</u> judgments of relative importance. In a global interpretation, relative importance is "a fixed attitude of the decision maker, a stable characteristic that doesn't depend on the particular stimuli involved, provided that the stimuli don't disturb the person's implicit contextual assumptions" (Goldstein, in press). A subjective relative importance judgment that is global, in that it could be applied to a new situation to produce valid causal predictions, could be very useful for instructing an agent to carry out one's preferences (Goldstein and Beattie, in press) or to predict outcomes the same way that an expert would predict them.

In a <u>local</u> interpretation of relative importance, on the other hand, a factor's importance could be determined by the particular characteristics of that factor in the situation under consideration (Goldstein, in press). For example, using a local definition of relative importance, fuel supply could be seen as more important in a situation where the fuel tanks were almost empty than in a situation where the tanks were full. Generally, the configuration of causes in the situation would invoke a particular pattern or "pragmatic reasoning schema" (c.f. Cheng, Holyoak, Nisbett, and Oliver, 1986), concerning evaluation of potential losses and gains. Each such schema would provide a different basis for calling aspects of the situation important. In contrast, a global definition of importance would call fuel supply equally important in both situations, because it takes account of the possibility of fuel shortage whether or not fuel is short in the present situation.

An alternative perspective on local versus global definitions of relative importance distinguishes them by asking, "What is the implicit population of situations for which the importance rating is expected to apply?" In this light, "local" relative importance applies to a set of situations whose features vary only slightly

from the present situation, while the "global" relative importance applies to a broader set of situations. Goldstein (in press) showed that people's judgments of relative importance, in a preference context, have characteristics of a local rather than a global definition. However, it was possible to change this by giving instructions emphasizing that the judgments were going to be used in another context (Goldstein and Mitzel, in press). In effect, these instructions called the subjects' attention to a broader set of situations.

For some purposes a global interpretation of relative importance is essential. Coates and McCourt (1976) elicited global relative importance judgments concerning the value of different aspects of order-of-battle intelligence. Dockery and Murray (1987) used approximate judgments of the degree to which a C^3 capability supports a particular aspect of the defense mission as a basis for fuzzy relative importance in a computerized decision aid for assessing the state of C^3 support. If informants had provided local relative importance judgments for either of these projects, then their judgments would have depended on the situations they happened to be thinking about, and the projects' analyses would have no general applicability.

For the purposes of command and control in a particular battle, a relatively local interpretation of predictive relative importance may be more useful than a global one. Local relative importance may give immediate guidance to decisions about how to allocate effort in order to influence the outcome, while global relative importance may require interpretation before it is applicable. Interpretation requires effort (hence might not be done) and is subject to error. A further issue is whether an alternative judgment, such as "impact" (Goldstein, in press; Hamm, Bursztajn, Mills, Appelbaum, and Gutheil, 1981) or more specifically "change in probability of success" (Hamm, 1990c), would be more useful for focussing effort in a battlefield context than a judgment of "relative importance".

Standards for judgments in complex, unique situations. It is essential that communications about uncertainty and importance be both understood (in that the recipient understands what the sender means) and accurate (in that what the sender says and what the receiver hears correspond to the situation). Although in a controlled laboratory situation it may be easy to measure what is more probable or more important, with realistic situations such standards are hard to come by. However, a rough evaluation of the quality of military officers' subjective assessments of the situation can be provided using analysis of the direction in which a reasonable judgment would change in the face of a change in the situation.

Prudence would demand that people's <u>probability</u> judgments be sensitive to changes in major causal aspects of the situation. For example, an officer facing a small force should believe with a higher level of probability that his mission will succeed than

an officer facing a large force, if all other factors in the two officers' situations are equal.

Whether people's <u>importance</u> judgments should be sensitive to a change in a causal factor depends on whether importance is defined locally or globally. An officer attacking an enemy on the move in the open should assess that his or her attack helicopters are more important (in a local sense) than those of an officer attacking a well prepared defense. However, if the officer is evaluating the importance of attack helicopters in general, it should not matter whether he or she happens to be thinking about an exposed or a defended enemy, because the importance judgment should cover both cases.

Further, locally- and globally-defined relative importance judgments should each be independent of trivial aspects of the presentation of the judgment problem. That is, there are some changes in the situation that should <u>not</u> affect relative importance judgments. For example, morale or mood is an important aspect of the functioning of military forces. Nonetheless, an officer's understanding of a situation, including his or her subjective judgments of the probability of success and of the relative importance of various causal factors, should be based on the solid information that is available rather than on the mood of the other people in the command post, unless that mood plays a causal role in the outcome. The Vincennes commander's decision to fire at the approaching airplane that turned out to be a civilian Iranian airliner was influenced by the stress and expectations on the bridge (Fogarty, 1988; Nisbett, 1988), and provides an extreme example of how judgments of probability or relative importance might be influenced by a general mood unrelated to the actual facts of the situation.

Issues addressed by the study. The present study investigated the accuracy of Army officers' subjective judgments of probability, and whether their relative importance judgments are local or global. Subjects were presented with a military battlefield situation and asked for their judgments of the probability of mission success and of the importance of several factors in the battlefield situation. In alternative versions of the situation presented to different subjects, the enemy's threat was varied. Do the subjects' assessments of the probability of success vary as a function of this key factor? Does their judgment of the importance of this factor vary? Another variable was an optimistic or pessimistic presentation of the situation. Where the changes in the objective situation are expected to influence the subjects' probabilities, and possibly their relative importance judgments, the changes in mood should not have such an effect.

The strength of the enemy, specifically the enemy's numbers in comparison with one's own numbers, has long been recognized as an important predictor of the outcome of battle. Methods of calculating the force ratio at particular locations in the

battlefield are taught as part of the curriculum in the Command and General Staff College, which the subjects of this study were attending. There has been technical debate concerning the validity of such general rules for estimating the probability of success as a function of the ratio of numbers of the attacking and defending forces (Helmbold, 1969; Stockfisch, 1975). The forces' experience in realistic training exercises, for example, can exercise more influence than relative numbers (Sulzen, 1987). Nonetheless, because relative strength is on the face of it a determining factor of battle outcome, and because the subjects had had explicit training in it, it was used as the objective factor that was varied in this study.

If subjective probability is to be a reliable form of communication about uncertainty, people's judgments of the probability of an outcome in a situation should not vary when the same information is presented in different orders. Thus, it should make no difference whether favorable details of a situation are presented first and unfavorable last, or vice versa. Research with military intelligence analysts has shown, however, that late arriving information has less impact on a probability judgment (Tolcott, Marvin, and Lehner, 1989). A related form of information variation is whether a fact is considered well established or hypothetical. This too should not affect people's probability judgments. For example, one should judge a coin flip as 50% likely to be heads, no matter whether one is told "the coin will definitely be flipped" or "suppose we were to flip the coin". Similarly, one should assign the same probabilities to outcomes in a situation with a particular constellation of factors, no matter whether that constellation is the best available description of reality, or a hypothetical description known to be different in one or more details from the actual case. However, one cognitive mechanism by which people make subjective judgments, the anchoring and adjustment heuristic (Hogarth, 1987), could produce different subjective probabilities for real and hypothetical situations. If people judge the probability of a hypothetical case by producing a careful assessment of the given situation, anchoring on that assessment, and adjusting it insufficiently in response to a hypothetical change in the situation, then the same situation may receive different probability assessments if called "hypothetical" or "actual".

The knowledge that enables quick understanding of a battlefield situation is pres mably acquired with years of experience. This has been characte..zed as "intuition", sometimes represented as a form of rapid pattern recognition (Dreyfus and Dreyfus, 1986; Klein, 1989) and other times as an averaging of the impacts of multiple inputs (Hammond, Hamm, Grassia, and Pearson, 1987). Whatever the details of the process, we would expect that the subjective probability and importance judgments of people who have had experience with military command and control would be more accurate than the judgments of people with no experience, such as college students. For comparison purposes, therefore, the

study was replicated with college students, including some in an Army ROTC program.

In summary, this study is concerned with three aspects of people's judgments about hypothetical military decision situations. The following predictions are made:

1. Probability judgments.

   a. The judged probability of an event in a battlefield situation (such as the success of a mission) will vary with changes in the facts of the situation, but it will not vary as a function of variations in the mood of the presentation that do not carry any information content.

   b. The judged probability of an event will not depend on whether the event is described as "given" or as a hypothetical variant of the given situation.

2. Relative importance judgments: In the absence of instructions to make global relative importance judgments, people's relative importance judgments will be local rather than global. Thus, changes in the situation may induce shifts in the relative importance of factors that are related to the change.

   a. Changes in the facts of the situation may induce shifts in relative importance, so that factors related to success or failure will be judged as more important when the facts make success or failure, respectively, more likely. Such changes would be legitimate with a local, but not with a global, definition of relative importance.

   b. Changes in the mood of the presentation may induce such shifts, so that factors that are related to the dominant mood of the presentation will be judged as more important. Such changes would not be legitimate with either a local or a global definition of relative importance.

3. Experience: Those with experience in military decision making will have more appropriate probability and relative importance judgments than those with no experience.

Procedure

The stimulus materials consisted of a typed booklet, including problem descriptions and questions, which the subjects read and responded to at their own pace.

Subjects. This questionnaire was sent by mail to 688 correspondence students of the U.S. Army Command and General

Staff College (CGSC), under a cover letter from the commander of the School of Corresponding Studies (SOCS).[1] All subjects received a postcard reminder after approximately one month. The booklet was also delivered to the mailboxes of 100 resident CGSC students at Fort Leavenworth, under a cover letter from the director of the Office of Evaluation and a hand written note from their instructor.[2] A third group was 130 introductory psychology students at the University of Colorado, who did the procedure in a group setting under the eye of a research assistant.[3] The final group was 24 Army ROTC students at the University of Colorado.[4]

In order to assure that the CGSC students had completed the Tactics course, which was deemed pertinent background for the problems, the questionnaire was mailed only to correspondence students who had completed at least Phase III of the self-paced curriculum, and it was given to the resident students after the Tactics section was completed.

Among the correspondence students, the questionnaire was mailed to soldiers in branches most likely to have had experience and training in battlefield situations: armor, artillery, aviation, engineers, and infantry. It was sent to students from three classes of service: active army, national guard, and reserves. There were a number of different versions of the questionnaire. These were allocated to the target groups in bundles (e.g., 2 bundles were sent to students in the infantry branch of the national guard), so that the same number of each questionnaire went to each type of subject. The overall return rate from the correspondence students did not differ significantly between branch or service class. The CGSC resident students were not selected on the basis of branch, and so officers from all branches were included.

There were two mailings, to different subsets of the list of qualifying CGSC correspondence students. One condition from each problem (Helicopter Neutral, and River Objective Success; see below) was included in the first mailing, and the remainder in the second. Also in the second mailing were questionnaires which gave outcome information for the same problems, reported in Hamm (1990d). Return rate was higher for the questionnaires of the present study that were in the second, fall mailing (42% of 168) than the first, summer mailing (29% of 520), presumably because of the time of year. Seventy-two of 100 questionnaires were returned by the resident CGSC students. Among the 293 responding military officers, 3.7% were lieutenant colonels, 72.1% majors, and 24.1% captains. The mean age was 38.1 (active army: 35.9;

national guard: 39.9; reserves: 39.5). Questionnaires were collected from all participating University of Colorado students though a small proportion of responses were not usable.

Mailed questionnaires were used with the military subjects in order to get a large number of subjects. The low return rate was anticipated. Although there is the danger that selective response might produce a sample whose judgments on these problems are not representative of that of the general population of Army officers, this was considered unlikely and a risk worth taking. Comparison between the CGSC resident students (72% response rate) and the correspondence students (33% response rate) can reveal differences that might suggest an effect of self-selected membership in the sample on the results. No differences were found between the two groups in the judged probability of success nor the judgments of relative importance. Further, probability of success was not related to variables that index experience (age, education, years in army, months in various command and staff positions). Therefore the military officers will be treated in what follows as one homogeneous group.

Materials. Two problems representing situations facing a military commander were used. In the Helicopter problem (Appendix A) a Company commander must respond to a helicopter heard to crash near his position. The mission is to find the helicopter and return with the injured or prisoners. In the River problem (Appendix B), a Battalion commander must plan an attack across a river.[5] The mission is to take a hill across the river by a particular time. The CGSC correspondence students received both problems. The CGSC resident students and the CU students received only the Helicopter problem.

Five versions of each of the problems were prepared (Table 1), varying expectation of success. Starting with the Neutral version (Helicopter (HN) in Appendix A, and River (RN) in Appendix B), two versions varied the objective threat presented by the enemy. The text that was varied is highlighted in the appendices. Table 2 shows the text that was substituted to produce the low threat (high expectation of success) and high threat (low expectation of success) versions. These will be referred to as the "Objective Success" (HOS and ROS) and "Objective Failure" (HOF and ROF) expectation conditions, and can be compared with the "Neutral" condition.

Table 1
Problem versions representing Objective and Subjective
manipulations of expectation of success.

Problem	Information Manipulated	Expectation of Success		
		Failure	Neutral	Success
Helicopter	Objective: Facts	HOF		HOS
			HN	
	Subjective: Presentation Mood	HSF		HSS
River	Objective: Facts	ROF		ROS
			RN	
	Subjective: Presentation Mood	RSF		RSS

The other two versions of each problem changed the mood of the
situation presentation, varying the tone but keeping the
objective information the same. Starting with the Neutral
condition (Appendices A and B), the text in the left column of
Table 3 (for the Helicopter problem) or Table 4 (for the River
problem) was substituted to create a subjective expectation of
failure (HSF and RSF), and the text in the right column was
substituted to create a subjective expectation of success (HSS
and RSS). Thus the mood or subjective presentation manipulation
is achieved by comparing the "Subjective Failure", "Neutral", and
"Subjective Success" conditions: HSF versus HN versus HSS, and
RSF versus RN versus RSS.

Table 2
Text conveying Objective manipulations of reader's expectations
concerning mission outcome.

Helicopter problem.

High objective enemy strength (Objective Failure condition, HOF):
"There has been particularly heavy enemy patrolling and
reconnaissance activity in this sector over the last several
days. Intelligence thinks that an attack may be imminent, and
warns that the company should be alert for troop infiltrations
and attacks on key installations."

Medium objective enemy strength (Neutral condition, HN): "There
has been little enemy activity in this sector, other than probes
and occasional contacts, over the last several days. Intelligence
does not think that an attack is imminent, but warns that the
company should be alert for reconnaissance patrols and probes."

Low objective enemy strength (Objective Success condition, HOS):
"There has been very little enemy activity in this sector
recently. Although there are usually some reconnaissance patrols
and probes, none have been observed over the last several days.
Intelligence thinks that some of the enemy forces may have been
moved to the north in support of a campaign in that area."

River Problem.

High objective enemy strength (Objective Failure condition, ROF):
"Intelligence reports that the enemy ... have been attrited to
90% strength."

Medium objective enemy strength (Neutral condition, RN):
"Intelligence reports that the enemy ... have been attrited to
70% strength."

Low objective enemy strength (Objective Success condition, ROS):
"Intelligence reports that the enemy ... have been attrited to
50% strength."

Table 3
Text conveying subjective manipulations of reader's expectations
concerning mission outcome, Helicopter problem.

Subjective Failure Condition (HSF)	Neutral Condition (HN)	Subjective Success Condition (HSS)
1. Nevertheless, Captain Smith reminds himself frequently that the enemy is a viciously efficient military force that has surprised U.S. forces a number of times in this conflict.	(Nothing said. Location: after "...last several days.")	Captain Smith and his men joke frequently about the enemy's legendary inefficiency.
2. ...thick ominous fog...intermittent light rain...	...thick fog... intermittent light rain...	...thick fog... intermittent gentle rain...
3. Good luck -- you are going to need it!	(Nothing said. Location: after "from the survivors or the wreckage.")	You should be able to pull it off successfully if you get a move on!
4. Capt. Smith notices that Lt. Wilson has doubts about the mission and is not eager to lead the patrol himself. Wilson decides...	Capt. Smith notices that Lt. Wilson is eager to lead the patrol himself, but Wilson decides...	Capt Smith notices that Lt. Wilson is confident about the mission and is eager to lead the patrol himself, but Wilson decides...
5. Jones, whose sloppy uniform and chronic frown reinforce the impression that he has let himself get out of shape, has led...	Jones has led...	Jones, whose military bearing accentuates his rugged appearance, has led...
6. As they take off, Sgt. Jones is heard to remark, "It probably came down right by an enemy patrol."	(Nothing said. Location: at end.)	As they take off, Sgt. Jones is heard to remark, "This will be a piece of cake."

Table 4
Text conveying subjective manipulations of reader's expectations
concerning mission outcome, River Problem.

Subjective Failure Condition (RSF)	Neutral Condition (RN)	Subjective Success Condition (RSS)
1. Because of the late hour he moves slowly, with the tension showing in his face.	(Nothing said. Location: after "plans for the next day's battle.")	Despite the late hour he moves briskly, projecting his total commitment and dedication.
2. ...several hours, and can be assumed to be vigorously preparing their defenses.	...several hours.	...several hours, and can be assumed to be exhausted.
3. Rubel is anxious that they might attack here tonight or tomorrow.	They are not likely to attack here tonight or tomorrow.	Rubel is confident that they will not attack here tonight or tomorrow.
4. ...they will be able to bring highly effective fire	...they will be able to bring fire	...they will probably be able to bring some fire
5. He hopes this will make it more difficult for them	This should make it more difficult for them	He is confident this will make it more difficult for them
6. Companies A and D will probably be able to cross ford X	Companies A and D will cross ford X	Companies A and D will be able to cross ford X
7. ...shift target... Hill 434. Hopefully this will prevent	...shift target... Hill 434. This will prevent	...shift target... Hill 434. This will prevent
8. Assuming the plan has worked thus far, the artillery will shift to suppressing	The artillery will shift to suppressing	The artillery will shift to suppressing
9. LTC Rubel heads off to sleep wondering whether the plan will work.	(Nothing said. Location: at end.)	LTC Rubel heads off to sleep quite confident that the plan will work.

After each problem, the subject was asked to (1) state the
probability that the mission would succeed, (2) revise the plan
to make it better, and (3) state the probability that his or her

revised plan would succeed. The subject was asked to revise the plan in order to assure careful consideration of the problem. The ROTC students, who participated in a group setting,[6] put considerable effort into this task, writing many paragraphs, while the introductory psychology students typically wrote only a few sentences. The amount of writing in the military officers' plans, which were produced in individual settings, varied widely. Then the subject (4) rated the relative importance of eight factors in the story, using two different methods. After the second problem, the subject (5) rated the two relative importance assessment methods on seven questions, (6) said which of the two methods he or she preferred, and (7) filled out a page of background information. The procedure could take from 10 minutes to an hour, depending on the amount of effort the subject put into it and on whether there were 1 or 2 problems. The method preferences and evaluations are presented in Hamm (1990b).

The factors whose relative importances were assessed in the Helicopter problem were either unknown aspects of the situation, or aspects of the commander's hurried plan: the fog in the valley where the crash occurred, the actual location of the crash, what the enemy is doing, the decision to send one patrol rather than two, the decision to send a small patrol, the choice of the most experienced man to lead the patrol, the choice of the most direct route to the estimated crash site, and the decision not to request aerial reconnaissance before sending out the patrol. The factors in the River problem were assumptions that were made in the problem: that the enemy has a given strength, that friendly artillery support is available, that the river can be forded, that vehicles can pass over the ground on the far side of the river, that the enemy does not occupy that ground, that the enemy has not completed preparation of defensive positions, that there will be no friendly air support, and that there will be no enemy air support.

Relative importance judgment methods. Three different methods for measuring relative importance were used in this study: Yes/No (subject indicated whether each factor was important or not); Rating (subject used a continuous numerical scale); and Probability Change (subject considered a change from the current level of each dimension and said what the probability of mission success would be if that were the case, all other factors being unchanged).

Instructions for each method started with a general definition of importance, in the context of the particular problem. For the River problem, "The success of LTC Rubel's attack plan depends on several important factors." The instructions continued as shown in the following paragraphs.

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6. The students' professor and program commander observed the session, which followed immediately after a talk about their future in the Army and about where among them the "cut" would fall this year.

Yes/No. "Please consider the following list, and judge whether each factor is important in determining the success of the attack." [Each of the 8 factors given above was listed, with "Yes/No" placed to its left.]

Rating. "Please consider the following list, and rate the factors according to their importance. Pick a fairly <u>unimportant</u> factor, and give it a score of '10'. Then give the other factors numbers that reflect how important they are, in relation to that first factor. Thus, you might give a very important factor a '200' because it is 20 times as important as the first, or you might give an unimportant factor a '5' because it is only half as important as the first factor. You can use fractions and can go as close to 0 as you want, or as high as you want." [Each factor was listed, with a blank to its left.]

Probability Change. "Please consider the following list, and estimate what the probability of attack success would be if the factor were to change as described. Please give specific probabilities. Each of the changes should be considered independently, leaving all other features as described originally. Refer to the 'Plan Evaluation' question to review your estimate of the probability that the attack will succeed in taking Hill 434 by 1200 given current conditions and LTC Rubel's original plan."

In this method the factors were presented in a unique manner. A specific alternative value, different from that given in the original problem presentation, was named. For example, in the River problem it is assumed that the attack will have artillery support: "two batteries of 155s... have been made available to the battalion during the morning hours...". The judgment of the relative importance of friendly artillery is elicited using, "What would be the probability of attack success if the brigade were not able to provide the battalion with full artillery support during the attack?" The questions for each of the factors are given in Appendices C (Helicopter problem) and D (River problem).

In the River problem, the Objective manipulation varied the enemy strength (50%, 70%, and 90% strength for the Objective Success, Neutral, and Objective Failure conditions, respectively). The question used in the Probability Change method to assess the importance of the enemy strength factor was "What would be the probability of attack success if the enemy in fact were at ___% strength?", with values of 75%, 90%, and 70% offered as hypothetical alternatives for 50%, 70%, and 90%, respectively. Because this variation in method makes it difficult to interpret the effects of changes in enemy strength on the resulting importance ratings, the Probability Change method will not be considered in discussing the results of manipulating enemy strength in the Objective conditions of the River problem.

Design. Some of the CGSC correspondence student subjects were part of a separate study that focussed on comparing the methods for measuring relative importance (Hamm, 1990a, 1990b). In the design of this study, the order of the problems (River or Helicopter first) was crossed systematically with which two methods (drawn from a set of five) were used. Thus subjects who did the Neutral condition for the Helicopter problem (HN in Table 1) also did the Objective, Success condition for the River problem (ROS). And they might have used any one or two of the three relative importance assessment methods whose results are reported here (see below). They used the same two methods, in the same order, on each of the two problems.

The remainder of the CGSC correspondence students were part of a second study in which each of the stories was varied. The Helicopter problem was always presented first. A particular condition on the Helicopter problem was always presented with a particular condition on the River problem. Thus, when the Helicopter problem had the Subjective, Failure (HSF) condition, it was followed by the Neutral condition of the River problem (RN). Other pairs were: (HSS, ROF), (HOF, RSS), and (HOS, RSF). Each subject did a "subjective" (or neutral) variant of one problem and an "objective" (or neutral) variant of the other. Crossed with the problem variations, subjects in this study assessed the relative importance of the factors using two of these three methods: Yes/No, Rating, Probability Change. The two methods were always presented in the order just listed. The fixed orders (Helicopter before River, and Yes/No before Rating before Probability Change) were selected so that the easier problem or procedure was done first.

The CGSC resident students and the University of Colorado students were given one of the five versions of the Helicopter problem. Their relative importance judgments were assessed using the Rating and then the Probability Change method.

Results

Probability judgments. Subjects estimated the probability of mission success after reading the description of the situation. There is no correct probability to compare their answers to, because the situations are hypothetical and incompletely described. However, subjects' probabilities were expected to change in response to changes in the facts of the situation, i.e., the objective description of the enemy's strength (HOF, HN, and HOS; ROF, RN, and ROS in Table 1), but not to change in response to changes in the mood of the presentation of the situation (HSF, HN, and HSS; RSF, RN, and RSS).

The CGSC students' mean subjective probabilities for the variants of the Helicopter problem are the bottom two curves in Figure 1 (the university students' curves will be discussed below). The judgments were highly variable: the mean within-condition standard deviation for the military officers on the Helicopter

problem was .186. The subjects' judgments of probability of mission success did not change monotonically with the manipulation of the facts about the enemy in the Objective scenario variants (solid line). The officers thought success was more likely in the Neutral condition (HN; mean probability = .57, n = 166) than in either the Success (HOS; .54, n = 29) or Failure (HOF; .49, n = 34) conditions. Overall, these fell short of differing significantly (F(2,227) = 1.9, p = .15); the Neutral condition (HN) was judged marginally significantly more likely to succeed than the Failure condition (HOF; t(198) = 1.9, p = .060).
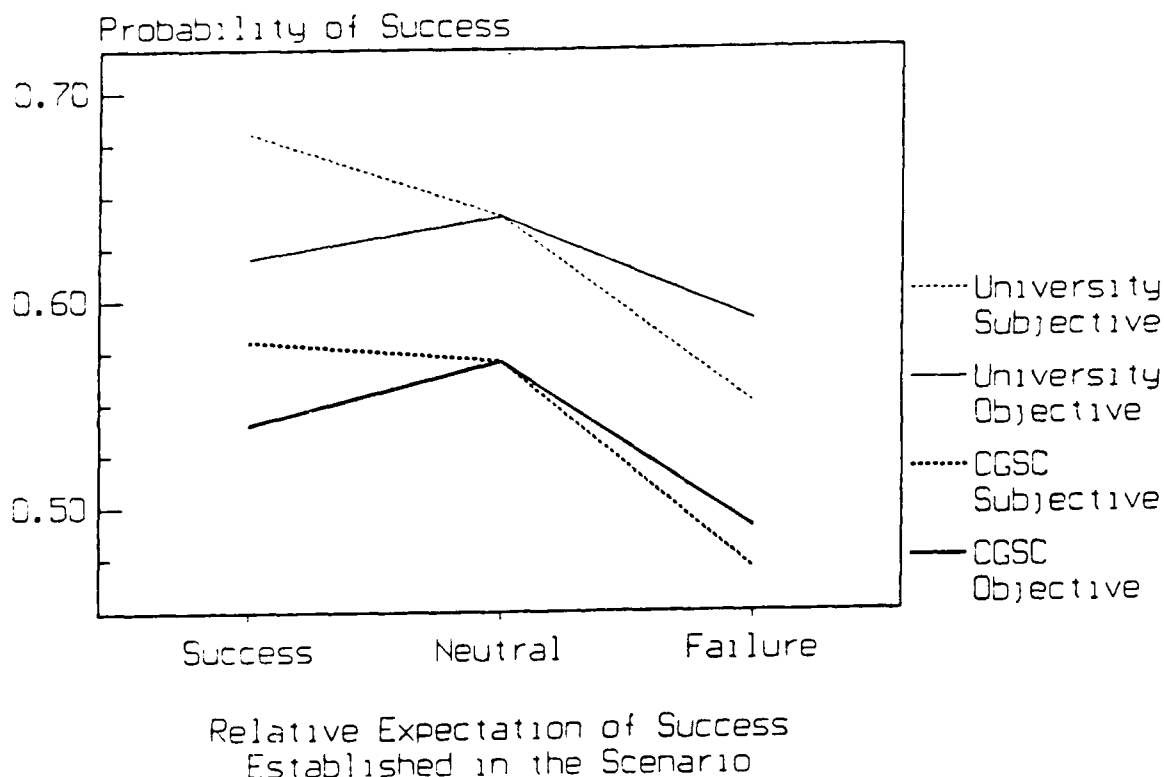
Figure 1. Judged probability of mission success, Helicopter problem, military and college students.

The probabilities of the Subjective variants of the Helicopter problem (dotted line in Figure 1) varied as a direct function of the mood of the presentation. Subjects judged the Success mood presentation (HSS) to have a .58 probability of success (n = 29); the Neutral presentation (HN) a .57 probability (as above; n = 166); and the Failure mood presentation (HSF) to have a .47 probability of success (n = 29). These differed significantly (F(2,222) = 3.1, p = .046). The judged probability of the Subjective Failure condition (HSF) was significantly less than

the Subjective Success condition (HSS; t(56) = 2.5, p = .014) and
than the Neutral condition (HN; t(193) = 2.4, p = .020).

The probabilities of success for Objective changes in the River
problem revealed a similar pattern to those on the Helicopter
problem (solid line in Figure 2). Again, the judged probability
of success was not a monotonic function of the enemy strength.
When the enemy was at 50% strength (Objective Success condition,
ROS) the mean probability of success was .61 (n = 150); with 70%
enemy strength (Neutral condition, RN), probability of success
was .70 (n = 14); and with 90% enemy strength (Objective Failure
condition, ROF), probability of success was .58 (n = 16).

Probability of Success
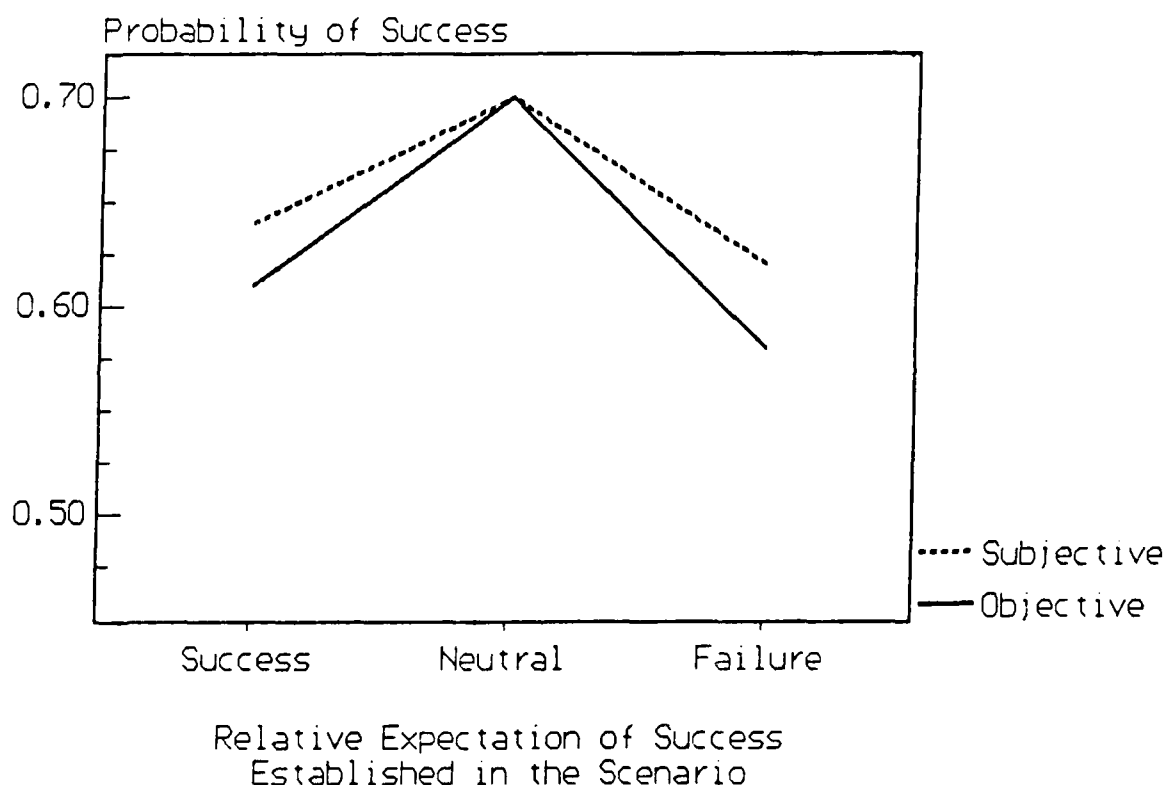
Figure 2. Judged probability of mission success, River problem,
CGSC correspondence students.

Overall this pattern was not conventionally significant (F(2,178)
= 2.2, p = .12), although the Neutral condition (RN) was judged
significantly more likely than the Success condition (ROS; t(162)
= -1.9 (counter expectations), p = .066) and than the Failure
condition (ROF; t(28) = 2.4, p = .025). Unlike in the Helicopter
problem, where the facts about the enemy were manipulated by

changing a number of verbal descriptions, the only aspect of the scenario varied in the Objective conditions of the River problem was the number representing the enemy strength. The lack of sensitivity to this important factor is surprising.

The probabilities of the Subjective variants of the River problem (dotted line in Figure 2) revealed the same pattern as the Objective variants: success was judged most likely in the middle or Neutral (RN) condition (.70; as above, n = 14). The mean probability of mission success in the Subjective, Success condition (RSS) was .64 (n = 18) and in the Subjective, Failure condition (RSF), .62 (n = 18). The differences among these and the Neutral condition are not statistically significant (F(2,48) = 0.9, p = .40).

Probabilities for the same situation when "given" versus "hypothetical". The Probability Change measure of relative importance asks subjects to judge the probability of mission success given a specified change in a factor. In the River problem, one of the factors whose importance was measured was the strength of the enemy. Thus, for the Neutral condition (RN) the given enemy strength was 70% and the subject was asked, "What would be the probability of attack success if the enemy in fact were at 90% strength?" However, the Objective manipulation varied the enemy strength given in the problem to 90% for the Objective Failure condition (ROF). Consequently it was necessary to have the subjects consider a <u>different</u> alternative enemy strength in the latter condition, and 70% was used. This gives an opportunity to test whether people judge an outcome to have the same probability when the situation is "given" or "hypothetical".

Subjects in the Objective Failure condition (ROF) who used the Probability Change method were told that the enemy was at 90% strength and asked to consider the probability of success if the enemy had been at 70% strength. In contrast, subjects in the Neutral condition (RN) were told that the enemy was at 70% strength and asked to consider the probability of success if the enemy had been at 90% strength. Each group, therefore, provides judgments of the probability of mission success when the enemy strength is at two levels: 70% and 90%. The difference is that one of these strengths is given as part of the original presentation of the scenario, while the other is considered as a hypothetical change from the original scenario. If subjects judge "hypothetical" and "given" scenarios identically, each scenario with a particular enemy strength should be assigned the same probability. On the other hand, if they use a process in which less attention is given to the hypothetical information, then the probability judgment may differ. Such a process, for example, might involve "anchoring" on the probability judgment for the given information and then "adjusting" the probability slightly in the direction implied by the hypothetical change in the situation.

The pattern of results is shown in Figure 3. Subjects in the Neutral condition (RN; $n = 10$[7]) judged the probability of success when enemy strength was 70% to be .71. When asked to consider the hypothetical situation in which the enemy strength was 90%, they changed their probability of mission success to .51. Subjects in the Objective Failure condition (ROF; $n = 10$) also estimated the probability of mission success to be .51 if the enemy was at 90% strength, but they increased it only to .60 (rather than to .71) in the hypothetical case of 70% strength. Thus, when the subject was given information that the enemy was strong (90% strength) and then considered a hypothetical situation in which the enemy was weak (70% strength), this weak enemy was judged to be more of a threat to the success of the mission than when it was given in the original description of the situation. This suggests that subjects may be anchoring on the probability assessments they make for the originally given information, and adjusting these probabilities insufficiently when asked to consider hypothetical changes in the situation.

A repeated measures analysis of variance tests the statistical significance of this effect. Mission success was judged more likely when enemy was weak than strong ($F(1,18) = 35.4$, $p = .000$), and the situation originally considered had more influence on the average judgment than the situation hypothetically considered ($F(1,18) = 4.8$, $p = .042$). However, the between-subject t-test between the two cells representing the judgments of the 70% strength enemy when this information was given in the problem, versus considered hypothetically, was not statistically significant ($t(18) = 1.4$, $p = .17$). Therefore, these results suggest but do not establish that officers anchor and insufficiently adjust, i.e., that they judge hypothetical changes in a situation differently from how they judge the focal situation.

Relative importance judgments. For each problem, subjects made relative importance judgments concerning each of 8 factors. The judgments were made using three different methods (Yes/No, Rating, and Probability Change; each subject used two of the three[8]). For comparison purposes, the judgments are translated to a common numerical scale.

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7. Only subjects who used the Probability Change method are included in this comparison, so the Ns are less than in the results presented above.

8. As explained above, some of the subjects who did the Helicopter Neutral (HN) and the River Objective Success (ROS) problems did less than two of these three methods, because subjects in this group used two out of a set of five methods; results with the other methods are not considered here.

Probability of Success

Strength of the Enemy
in the Situation Judged
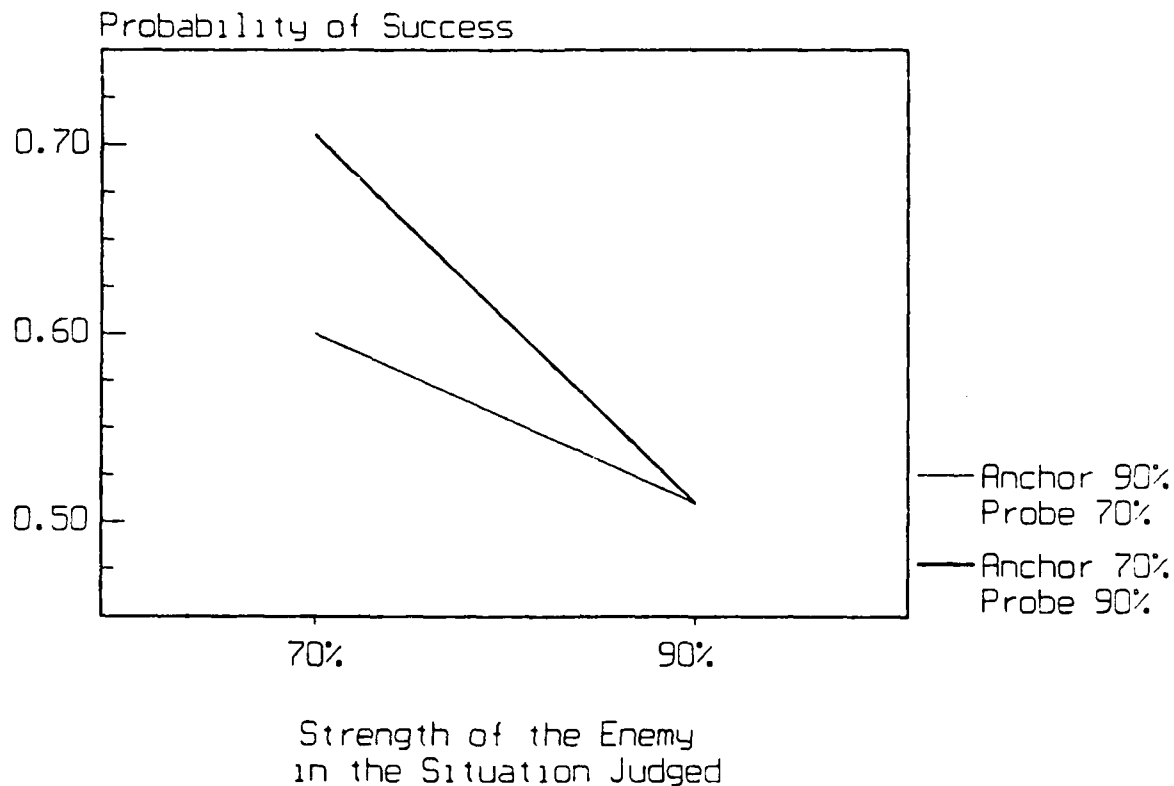
Figure 3. Probability of success for two levels of enemy
strength, as a function of whether the level is given in the
original situation or considered as a hypothetical alternative.

To do this, the subjects' judgments are rescaled onto a numerical
scale, and then the numerical scales from the different methods
are normalized to produce a common scale. Yes/no responses were
rescaled as follows: Yes = 1, No = 0. Rating responses did not
need to be rescaled prior to normalization. For the probability
change method, importance was measured by the absolute value of
the difference between the original estimate of the plan's
probability of success and the revised estimate given the changed
factor.

Normalization was accomplished by dividing each factor's
numerical importance measure by the sum over all 8 factors. This
produced a number ranging between 0 and 1 for each factor, with a
total of 1 over all 8 factors and hence an expected value of
.125. Normalization was done only for those subjects who gave an
answer for all 8 factors; otherwise the subject's data on the
measure were not further used. Finally, summary measures of

relative importance can be created by averaging the normalized scores for several methods.

On the rating method four of the CGSC subjects appeared to have rank ordered the factors - they used each of the numbers from 1 to 8. Because of the ambiguity -- a low rank is important, while a high rating is important -- it was necessary to drop these subjects' ratings.

On the River problem, with the probability change importance judgment method, the question used to assess the importance of the enemy's strength was varied between Objective conditions because the actual enemy strength itself was varied (see above). This variation makes it inappropriate to use the probability change measure for comparing the Objective conditions on the River problem.

Local versus global judgments of relative importance. The Yes/No and Rating methods can be used either locally or globally. In contrast, the Probability Change method is explicitly local. Therefore only the Yes/No and Rating methods can be used to test whether subjects spontaneously adopt a local or global interpretation.

A local interpretation of relative importance is suggested if the relative importance rating for a factor changes when the level of the factor in the particular situation changes. Such a change would be inconsistent with a global, and consistent with a local, interpretation of relative importance. Lack of change does not disprove a local interpretation, although it is more consistent with a global interpretation.

The Objective conditions explicitly varied the level or value of a factor in the situation (see Table 2). For both problems, this factor was the enemy threat: the "enemy acts" factor in the Helicopter problem, and the "enemy strength" factor in the River problem (see Appendices C and D). The judged importance of the varied factor (mean of normalized Yes/No and Rating responses) changed very little in the Helicopter problem (Objective, Enemy Acts factor: thin solid line [HOF versus HN versus HOS] in Figure 4; $F(2,173) = 0.2$, $p = .81$). Change was insignificant in the River problem as well (Objective, Enemy Strength factor: thin solid line [ROF versus RN versus ROS] in Figure 5; $F(2,105) = 0.5$, $p = .59$). This suggests that people use relative importance in a global sense.

Normalized Relative Importance

Figure 4. Relative importance of specific factors, Helicopter problem, objective and subjective conditions, military officers.

The purpose of the Subjective manipulations was to change expectation through manipulation of mood and characters' feelings. It was not our intent to manipulate any of the actual factors in the situation. However, inspection of the problem variants shows that some of the manipulation sentences might be construed as changing the cue values of some of the factors. Specifically, in the Helicopter problem changes 1 and 6 (see Table 3) had to do with the enemy, and changes 4 and 5 had to do with the choice of the more experienced man as leader of the patrol. In the River problem, changes 2 and 4 (in Table 4) had to do with the enemy's strength, change 6 with the commander's forces' ability to ford the river, and change 8 with the power of the friendly artillery. Because of the possibility that these factors were changed by the Subjective manipulations, we will check to see whether subjects' judgments of the relative importance of these factors was affected. A change would support the hypothesis that subjects make relative importance judgments in a local manner. But because the manipulation of the factors

was minor, if there were no change it would provide only weak evidence that they judge relative importance globally.
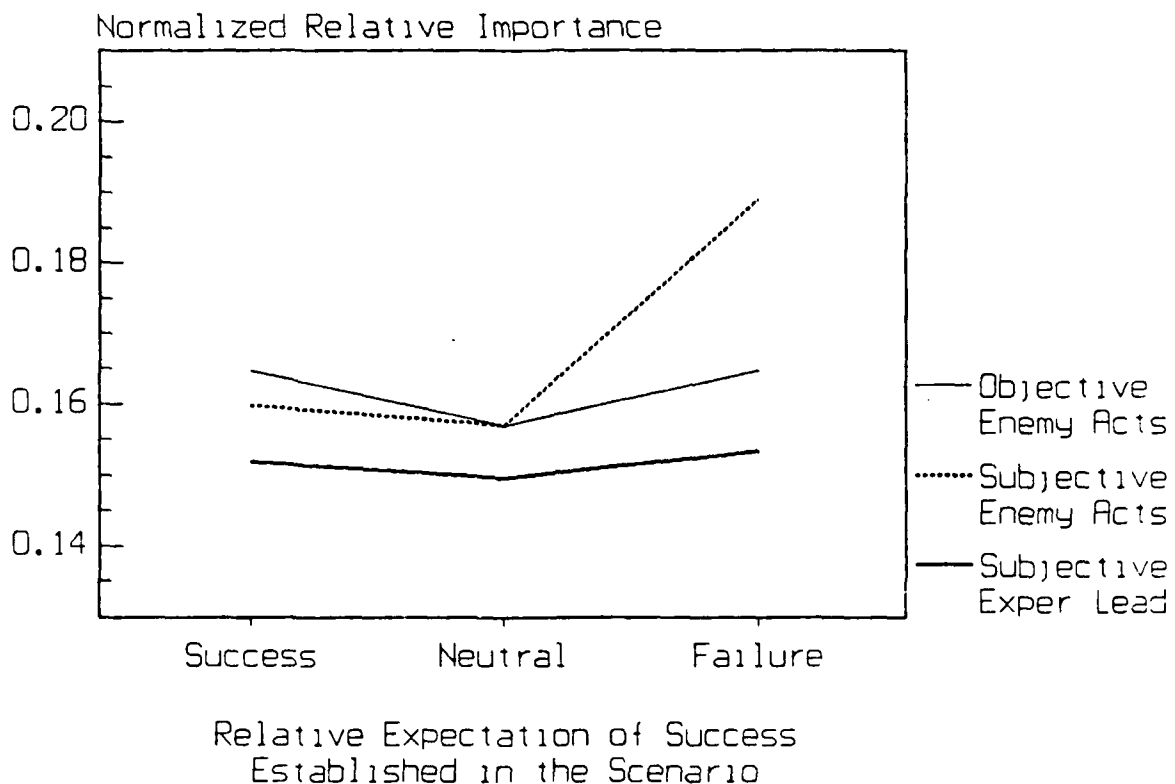
Normalized Relative Importance
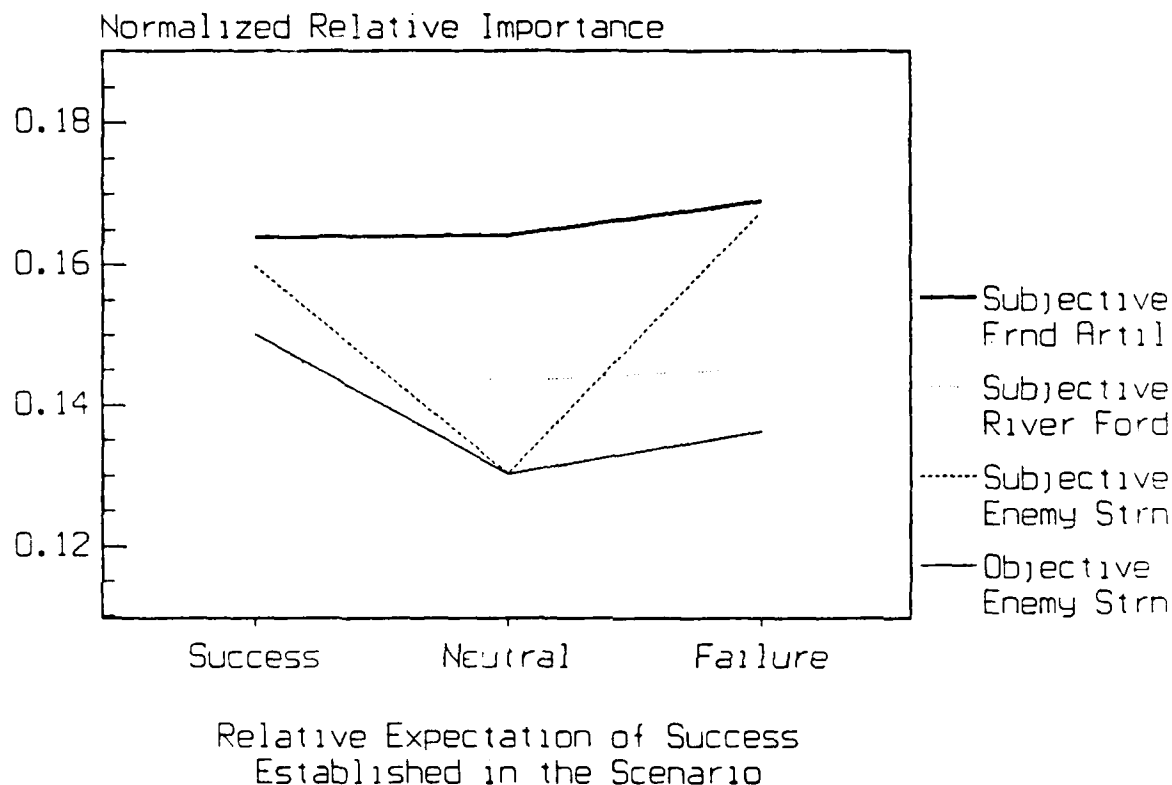
Figure 5. Relative importance of specific factors, River problem, objective and subjective conditions, military officers.

Subjects' relative importance ratings for these factors did not vary significantly as an effect of the Subjective manipulation of the expectation of success through the mood of the presentation (see Figures 4 and 5). Helicopter problem results (HSS versus HN versus HSF): Enemy Acts factor ($F(2,162) = 2.1$, $p = .13$); Experienced Man factor ($F(2,162) = 0.03$, $p = .97$). River problem results (RSS versus RN versus RSF): Enemy Strength factor ($F(2,37) = 1.4$, $p = .26$); Artillery factor ($F(2,37) = 0.02$, $p = .98$); River Fordability factor ($F(2,37) = 0.01$, $p = .99$). For both problems, the evidence from those factors that were directly manipulated, either Objectively or Subjectively, suggests that when using the Yes/No and Rating methods to assess relative importance, people have a global rather than a local interpretation of relative importance.

Halo effects. People actively construct their image of the world. When they do so, we might expect that information about one

factor may influence the interpretation of information about other factors. This could produce a "halo effect" with relative importance judgments: as the probability of success increases, those factors that are consistent with success might come to be seen as more important, and factors that are more consistent with failure as less important. Oppositely, as failure becomes more likely, the factors consistent with failure might be seen as more important. Such a halo effect can only occur given a local interpretation of relative importance; under a global interpretation, the probabilities in the particular case should not affect the relative importance of the factors, which should be universal. A halo effect on a local measure of relative importance might more legitimately occur if the expectation of success is manipulated objectively, i.e., by changing the facts of the situation; if it were to occur when the mood of the presentation is manipulated, it would suggest people are too easily swayed by subjective aspects of the situation.

To look for such a halo effect, the factors were analyzed a priori to see whether they contribute to success or to failure, or whether the relation is uncertain (it is not known what will happen) or ambivalent (unclear whether it helps or hinders the attainment of the goal). For the Helicopter problem, the factors in the story that contribute primarily to failure are that only one patrol is sent, that the patrol is small, and that there will be no air reconnaissance. The choice of experienced leader contributes to success. The true location of the crash and the response of the enemy are uncertain. The roles of the fog and the chosen route are ambivalent (fog hinders visibility yet provides cover; the direct route gets the patrol rapidly to the probable crash site, yet can be predicted by the enemy). For the River problem, the lack of friendly air support contributes to failure. The available friendly artillery, the fordability of the stream, and the lack of enemy air support contribute to success. The enemy strength, the ability of vehicles to approach the enemy positions, the extent of enemy defenses, and whether the enemy has positions on the plain are all uncertain. Because subjects did not indicate any significant differences in the relative importance of the factors that were changed in either the Objective or Subjective manipulation, those factors are included in this general analysis.

For the general analysis, the factors are grouped into three sets: tending to success, tending to failure, or uncertain/ambivalent. The relative importance indices (the within subject means of the normalized Yes/No and Rating measures) for each of the factors in a set are averaged, within subject, to produce each of the three factor set scores. The analysis will look at the across-subject means of each of these sets as the expectation changes. If there is a halo effect, it will be manifest in the sets of factors having different slopes as a function of expectation.

Let us first consider the halo effects due to manipulation of Objective factors pertinent to the expectation of mission success (Figures 6 and 7). First, note that the factors that contribute to success were generally considered more important than those that contribute to failure.[9] In addition, a similar pattern was seen for both problems: as the expectation of success decreased, the ratings of the success and the failure factors converged. That is, the judged importance of the factors that contribute to success was larger in the conditions where success was expected than where failure was expected (for both problems), and the judged importance of the factors that contribute to failure was larger in the conditions where failure was expected (especially for the River problem).
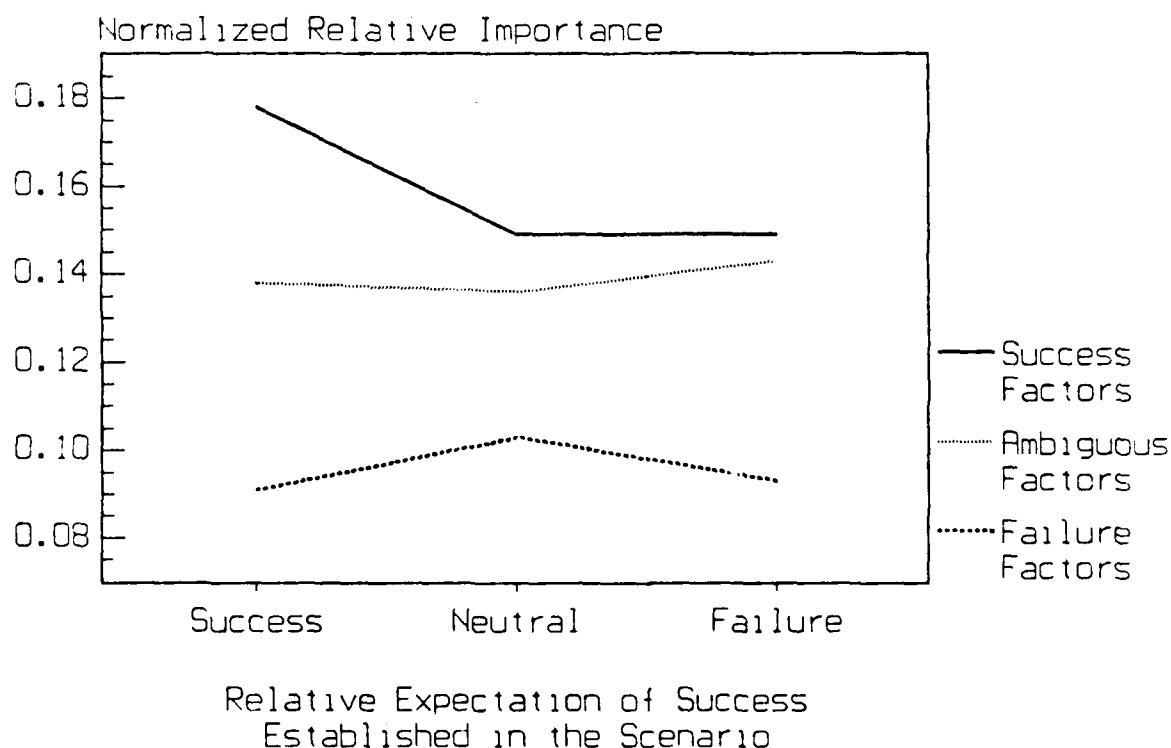
Figure 6. Relative importance of general factors, Helicopter problem, objective conditions, military officers.

This convergence embodies the halo effect of interest, and is represented by the interaction term in a repeated measures

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9. It is not known whether this is due to the way the problems happen to have been written, or reflects people's propensity when assessing situations to attend to the factors that lead to success rather than to failure.

analysis of variance. The pattern was statistically significant in the River problem (all 9 data points: $F(4,210) = 2.47$, $p = .046$; the 4 corner points: $F(1,96) = 4.21$, $p = .043$), but not in the Helicopter problem (all 9 data points: $F(4,346) = 1.30$, $p = .27$; the 4 corner points: $F(1,64) = 1.34$, $p = .25$). As argued above, this effect indicates that the relative importance · judgments are local rather than global.
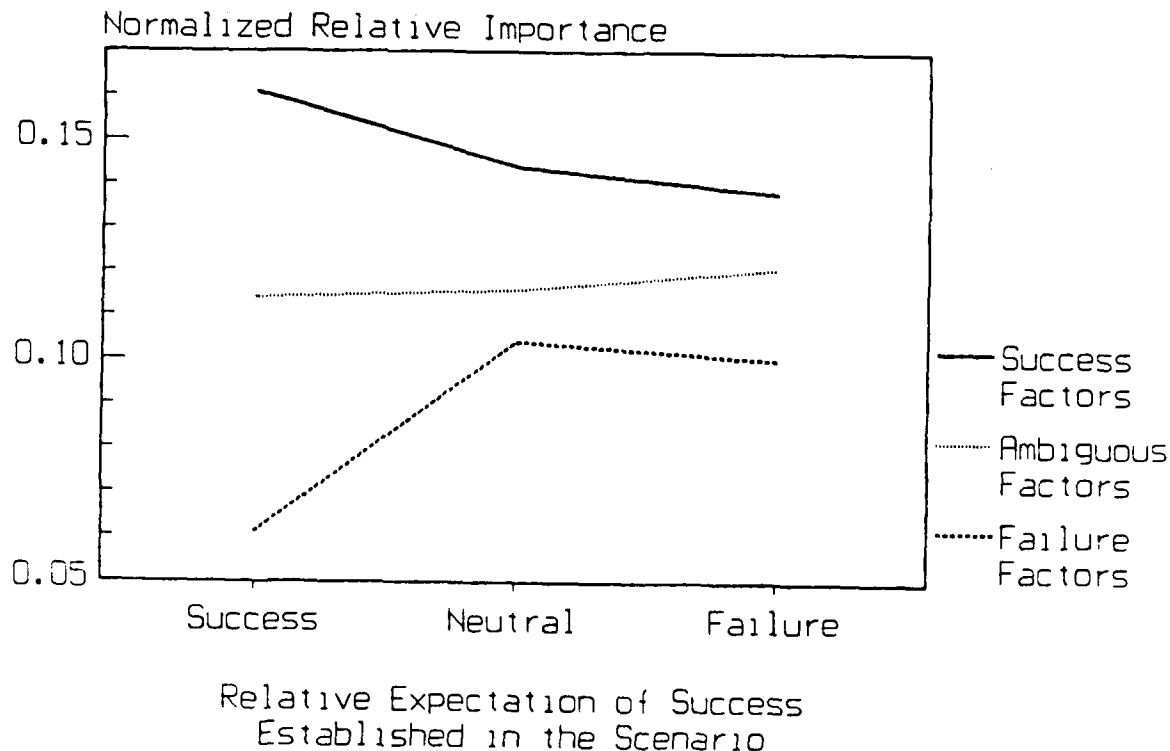
Figure 7. Relative importance of general factors, River problem, objective conditions, military officers.

No convergence pattern signifying a halo effect was visible in response to the Subjective manipulations, and the interactions were not statistically significant.

In summary, subjects' judgments of the relative importance of factors in the situation did not change significantly when those factors were explicitly changed, in either the Objective or Subjective manipulation conditions. Thus, direct evidence of the local use of the relative importance judgments was not seen. However, a hypothesized halo effect was found in response to the Objective manipulations of expectation of success: when success was more likely, factors in the story that contribute to success

were judged more important and factors that contribute to failure
less important. This pattern was observed in both the River
problem and the Helicopter problem, but was statistically
significant only in the River problem. The pattern was not found
with the Subjective manipulations. This halo effect is consistent
with a local rather than a global interpretation of relative
importance.

Probability change as a local measure of relative importance.
Subjects' judgments using the Yes/No and Rating methods behaved
consistent with a global interpretation, except for the halo
effect in the Objective conditions on the River problem. However,
in some situations it may be an advantage for a measure of
relative importance to be local rather than global. The
Probability Change measure is explicitly local: the subject is
asked to say how much a hypothetical change from the level of a
factor specified in the situation would change the probability of
success. The larger the change in probability, the more
"important" the factor.[10]

Are there "local" shifts in this measure of relative importance
in response to changes in the situation, as would be expected? We
will look at the effects of the Objective and Subjective
manipulations of expectation on the subjects' Probability Change
judgments for the individual factors.[11] To make the judgments
easily interpretable, we will display the probability change (the
probability of mission success if the factor were changed as
specified, minus the original estimate of the probability) rather
than the normalized, absolute value of the probability change
(which serves as a general measure of relative importance).

For the Helicopter problem, the upper section in Table 5 shows
the effect of Objectively manipulating the expectation of
success. None of the 8 factors had a change in importance that
was significant at less than $p = .125$.[12] For example, the
importance of the enemy's actions (the probability of mission
success "if the enemy were able to see where the helicopter had
crashed and had already sent two patrols") did not change
significantly when expectation changed from success to failure
$(F(2,127) = 0.8, p = .45)$.

When the expectation of success on the Helicopter problem was
Subjectively manipulated (lower section of Table 5), there were
several changes. For example, when success became less likely,
the anticipated _decrease_ in probability of mission success due to

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10. The amount of probability change also depends on the size of the change in the factor. Negating or
    reversing each factor is one way to establish equal amounts of change (e.g., to remove artillery support
    or add air support), so that differences in amount of probability change can be attributed solely to the
    factors' importance; but it is not possible to "negate" a continuous factor such as enemy strength.

11. Because the direction and extent of the local changes depends on the particular hypothetical level that
    the subject was asked to judge, it does not make sense to combine the individual factors into sets.

12. Given 8 factors, it is expected that one would be significant at less than .125 by chance.

the hypothetical choice of a less-experienced patrol leader
lessened (from -.104 to -.026; F(2,117) = 3.7, p = .028; linear
trend F(1,118) = 3.0, p = .088). Six of the 8 factors were
affected at p < .125, and 5 had linear trends that were
significant at p < .125.

Table 5

Effects of Objective and Subjective manipulations on relative importance
of factors, measured with the Probability Change method, Helicopter
problem.

Objective.

Factor	Success HOS	Neutral HN	Failure HOF	N	General Test F(2,N-2)	p	Test of Linear Trend F(1,N-1)	p
Fog	-.001	.036	.058	128	0.6	.53	1.2	.27
Enemy Acts[a]	-.322	-.292	-.242	127	0.8	.45	1.6	.22
Location	-.174	-.184	-.156	127	0.2	.82	0.1	.72
Experncd Man	-.082	-.129	-.078	125	1.4	.26	0.0	.85
Route	-.099	-.125	-.065	127	1.1	.32	0.6	.45
One patrol	.125	.116	.120	127	0.0	.97	0.0	.93
Small patrol	.030	.055	.064	125	0.2	.78	0.4	.51
Aerial recon	.004	.008	.030	122	0.1	.88	0.2	.66

Subjective.

Factor	Success HSS	Neutral HN	Failure HSF	N	General Test F(2,N-2)	p	Test of Linear Trend F(1,N-1)	p
Fog	-.011	.036	.082	122	1.5	.24	2.9	.091
Enemy Acts[a]	-.396	-.292	-.281	121	2.2	.114	3.1	.079
Location	-.198	-.184	-.094	121	2.4	.095	3.7	.057
Experncd Man[a]	-.104	-.129	-.026	119	3.7	.028	3.0	.088
Route	-.117	-.125	-.033	121	2.4	.093	2.7	.102
One patrol	.157	.116	.195	120	2.9	.057	1.0	.32
Small patrol	.126	.055	.140	119	2.9	.061	0.1	.73
Aerial recon	.039	.008	.108	116	2.2	.130	1.4	.25

[a]These factors were directly manipulated.

For the River problem (Table 6), the Probability Change measure
of the importance of enemy strength was flawed for the Objective
variations, as discussed above, and so is not used here. The
probability change judgments of 4 of the other 7 factors (upper
section of Table 6) were affected at a significance level of p <
.143 (three of them having linear trends significant at p <
.143). When the expectation of success was changed through
Subjective manipulations, on the other hand, only the artillery
factor showed any effect (lower section of Table 6): as the
expectation of success decreased, the anticipated decrease in the
probability of mission success "if the brigade were not able to
provide the battalion with field artillery support during the

attack" lessened, with the linear trend nearly significant at
.057.

Table 6
Effects of Objective and Subjective manipulations on relative importance
of factors, measured with the Probability Change method, River problem.

Objective.

Factor	Success ROS	Neutral RN	Failure ROF	N	General Test F(2,N-2)	p	Test of Linear Trend F(1,N-1)	p
Enemy Streng[a]								
Artillery	-.243	-.292	-.195	77	1.3	.28	0.2	.63
Fordability	-.344	-.383	-.215	73	2.8	.069	2.6	.113
Veh Passage	-.272	-.383	-.220	77	3.8	.027	0.0	.97
Defen Posit	-.264	-.263	-.205	78	0.7	.50	1.1	.30
En on Ground	-.195	-.252	-.130	77	1.9	.15	0.5	.48
Friendly Air	.113	.067	.269	78	10.9	.000	10.1	.0022
Enemy Air	-.312	-.425	-.115	74	6.5	.0025	3.4	.0695

Subjective.

Factor	Success RSS	Neutral RN	Failure RSF	N	General Test F(2,N-2)	p	Test of Linear Trend F(1,N-1)	p
Enemy Streng[a]	-.258	-.188	-.185	37	0.9	.40	1.5	.23
Artillery[a]	-.323	-.292	-.223	37	2.0	.15	3.9	.057
Fordability[a]	-.320	-.383	-.381	37	0.3	.72	0.5	.50
Veh Passage	-.249	-.383	-.308	37	1.5	.23	0.6	.44
Defen Posit	-.296	-.263	-.258	37	0.2	.84	0.3	.59
En on Ground	-.246	-.251	-.169	37	1.6	.22	2.2	.14
Friendly Air	.106	.067	.127	37	0.9	.41	0.2	.64
Enemy Air	-.356	-.425	-.294	37	2.1	.14	1.0	.33

[a]These factors were directly manipulated.

The contrast between the effects of the Objective and Subjective
manipulations for the River problem is most evident with the
Friendly Air Support and Enemy Air Support factors (Figure 8). In
the original scenario, it was anticipated that neither side would
have air support. When the reader expected failure because of the
objective fact that the enemy was at 90% strength, the change in
mission success probability if "it were possible for LTC Rubel to
be supported by five attack helicopters" increased from a .11
gain (for 50% strength) or a .06 gain (for 70%) to a .27 gain
(for 90%). Similarly, the decrease in mission success probability
if "the enemy were to have fighter and attack helicopter support"
lessened from a -.31 loss (for 50%) or -.43 loss (for 70%) to a
-.12 loss. When the expectation of failure was created using the
subjective manipulation of the mood of the scenario presentation,
the changes were smaller and statistically insignificant.
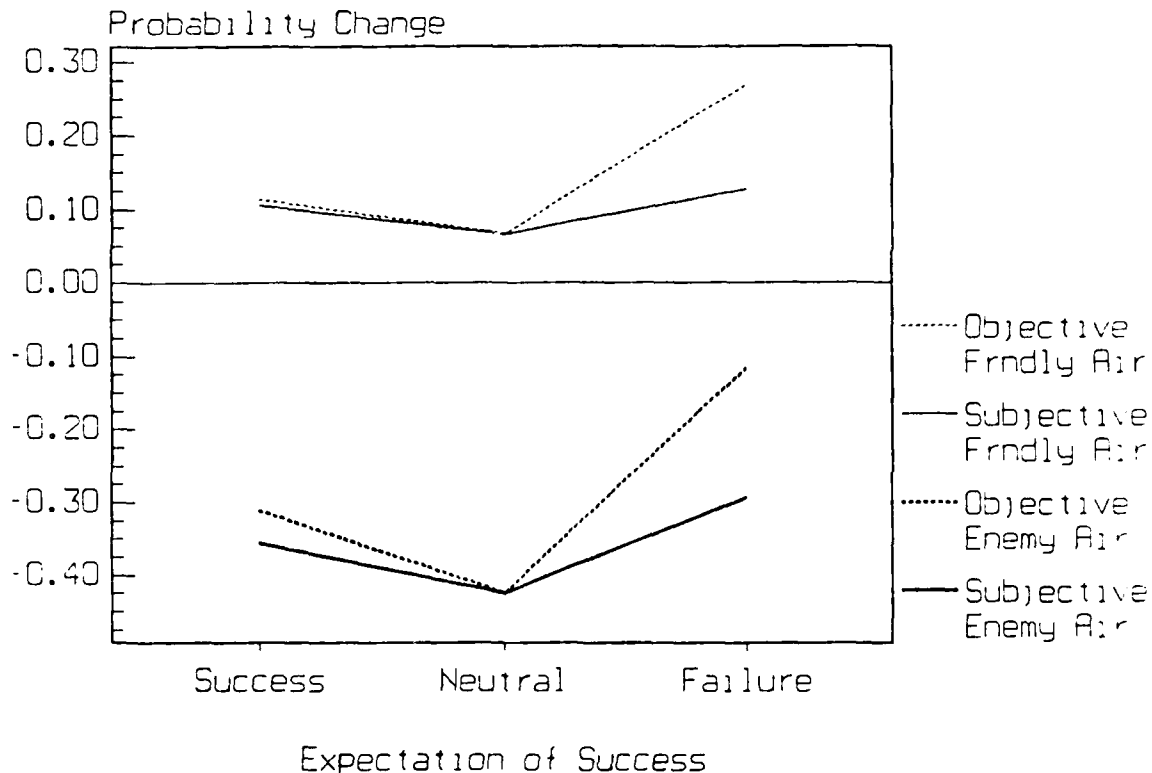
Figure 8. Effects of scenario variations on raw Probability Change judgments.

Unlike a global measure of relative importance, which should not be sensitive to changes in the particular levels of the factors in the situation, factor importance measured by a local relative importance method can be expected to shift as the situation changes. Shifts in response to changes in the Subjective presentation of the situation would not be desirable. Change in the Objective enemy threat in the River problem produced interpretable changes in the importance of non-manipulated factors, as measured with the Probability Change method, but changes in the Subjective presentation of the situation produced none. In contrast, on the Helicopter problem the Subjective changes produced nearly significant changes while the Objective change in the enemy's behavior produced none. These unusual results on the Helicopter problem are consistent with the finding (above) that the Objective manipulation did not affect its probability of success while the Subjective manipulation did, and with findings concerning hindsight bias with these two problems (Hamm, 1990d).

Effects of expertise. The military officer subjects, regardless of branch, are familiar with the general battlefield situation. They have all had formal education in the CGSC courses; in addition, a number of them have had extensive experience as commanders of low level units or on staffs at various echelons, including Vietnam combat experience for some members of the reserves and national guard (who are older than the active army subjects). Therefore, while they may not be experts, they are competent and familiar with the general situation. In contrast, the college students know nothing about handling battle situations, other than what is available in the general culture. The ROTC students have more exposure to and interest in battle situations, but not to the extent of the career military officers. Therefore differences between the judgments of military officers and college students can be expected.

Comparison of the subjects' probabilities of mission success for the Helicopter problem (Figure 1) shows that the students generally estimated higher probabilities than the military officers (F(1,444) = 14.6, p = .000), but otherwise the pattern of probabilities over the 5 conditions was identical, including the nonmonotonic response to the objective change in the enemy threat. In fact, the ROTC students were the only group in the study for whom there was, on average, a higher probability of success when the enemy presented a low objective threat (.69, n = 4) compared to an average objective threat (.59, n = 6).

To determine whether there were any differences between college and CGSC students in the pattern of their relative importance ratings, in response to changes in expectation, a repeated measures analysis of variance (8 factors by three conditions by college/CGSC) was done. The Factor by Condition by Group interaction was not significant for either the objective or the subjective manipulation of expectations. Therefore there is no evidence that people with military experience assess the relative importance of causal factors in a battlefield situation any differently than people with no military experience.

Discussion

Probability of success insensitive to enemy strength. Subjects' judgments of the probability of mission success did not shift in the predicted manner as the objective enemy threat in the situation was changed. In each problem, the commander's mission was judged to have a higher probability of success in the medium threat (Neutral) condition than in the low threat (Objective Success) condition. Although this non-monotonic relation between enemy threat and probability of success fell short of conventional statistical significance in each problem (.10 < p < .15), the fact that the same pattern occurred on both the River and the Helicopter problems (and also when the college students did the Helicopter problem) means it should be taken seriously. In the River problem, there were few subjects in the discrepant Neutral condition, so the non-monotonic relationship might be

dismissed as a chance outcome. However, if we ignore the Neutral condition, there still was no difference between the probabilities of success when the enemy in the River problem was at 50% and 90% strength, nor when the enemy in the Helicopter problem was expected to be present or absent, and so the conclusion that the subjects' probabilities are not responding to variation in an important aspect of the situation still stands.

The finding is not due to subjects inferring that the enemy gains experience as it loses men. A plausible line of reasoning for the River problem might go: If the war has just started, a unit at 90% strength may still have limited experience; by the time it is at 70% strength it may have gained experience and still be able to fight; and when at 50% strength it is no longer able to fight despite its experience. The combination of declining strength and increasing experience might produce an enemy which offers the greatest threat when at medium rather than high strength. The implications of this line of reasoning for our side's probability of success, however, would be a U-shaped curve, the inverse pattern from what was observed here.

The finding that military officers' numerical probability judgments are not accurate may have limited generality. It has been demonstrated here with between-subject judgments, where one group of subjects looks at Situation A and another looks at Situation B. Their judgments may be more accurate when each individual compares more than one situation (as they did in the Probability Change method; see below). Further, the Helicopter problem is unusual in that it involves great uncertainty. One might reasonably argue that knowledge about the enemy's competence and activity level is not pertinent to an estimate of the probability that the helicopter would be rescued in this situation.

But it is impossible to ignore the insensitivity to the enemy's strength in the River problem. Common sense identifies the enemy as a very important element of the situation. In addition, the CGSC students have been taught a rule of thumb which explicitly relates enemy strength to the probability of attack success. This is the force ratio rule: the ratio of attackers to defenders must be 3 to 1 to have a 50% chance of attack success. It can be used for determining whether one should seek more men for an attack, or as a tool for a more precise prediction. The detailed information required for the application of particular formulas expressing the force ratio rule is not present in the scenario, and indeed the officers may be aware that the use of particular formulas has been criticized (Helmbold, 1969). Nonetheless, they should have learned to think intuitively about relative strengths in this sort of situation, so that differences between 90% and 50% enemy strength, all other factors staying constant, would affect their judgments of the probability of mission success. The question is whether the demonstrated insensitivity to enemy strength indicates a superficial difficulty in using probabilities, say in calibrating them when making a one-shot

judgment, or a deeper difficulty in grasping the dynamics of a battlefield situation.

The subjects' performance cn the relative importance judgment task offers evidence pertinent to this question. Subjects revealed a "halo effect" when the enemy strength information was varied in the River problem: when the enemy was stronger, they judged the failure-related factors to be more important and the success-related factors to be less important. This subtle effect shows that the military officers were paying fundamental attention to the enemy's strength. Perhaps this is at the encoding or pattern recognition stage rather than at the time of judgment. This implies that the officers' inappropriate probability judgments are due to their difficulty using probabilities rather than to an inability to comprehend the implication of enemy strength on the battlefield.

Probability of success sensitive to mood of situation presentation. The Subjective conditions varied the expectation of success through changes in the mood of the scenario: how the environment and the actors were described, and how the actors felt. The subjects' probability judgments should not respond to these variations in mood, and indeed they did not in the River problem. However, the manipulation of the subjective expectation of success through mood elements in the presentation of the Helicopter problem significantly affected the subjects' judgments of the probability of mission success.

The amount of information manipulated does not account for the effect of the Subjective manipulations. In the Objective conditions for the Helicopter problem, the content of only one paragraph was varied (Table 2), while in the Subjective conditions, six paragraphs were varied (Table 3). Thus the psychological stimulus was more powerful in the Subjective conditions, and so it is not surprising that the subjects responded more than to the Objective variation. Applying the same argument to the River problem, it should not be surprising that the Objective variants had no impact, since only one fact was varied (Table 2). But by the same token, nine pieces of information were manipulated in the Subjective conditions of the River problem (Table 4), yet these did not have a significant effect. Therefore the amount of information varied between the conditions does not, by itself, explain why some conditions had effects and other conditions did not.

The effect of the subjective variations may be due to the nature of the Helicopter problem. The causal factors controlling success here may be so ambiguous that the subjects feel at a loss to make a probability estimate. Indeed, their probability judgments were not significantly affected by the changes in the objective factor, the enemy's activity level. In ambiguous conditions subjects may be influenced by mood information that they would not attend to otherwise.

Although no objective information varied between the Subjective (presentation mood) conditions, it may be appropriate for military officers to attend to the information that was varied. Attending to the way other people say and do things may be justified, because such information may be pertinent on a battlefield. Exhausted leaders or demoralized subordinates may not fight as well. In most real world situations, there is a strong association between what people are excited about and what is important. Further, information about what other people think and feel is used to communicate informally about what groups should be attending to (Hamm, 1989). If officers had to explain everything in explicit formal statements, it would take them longer (Linville, Liebhaber, Obermayer, and Fallesen, 1989) and they would communicate less. Therefore people's use of subjective cues is not in itself a matter of concern, because such information would be present in a battlefield and would probably provide valid cues to what is important there. It would be a problem only if these subjective cues were misleading.

Finally, it might be argued that this study's demonstration that people's probability estimates respond more to variations in subjective mood than to changes in objective facts is irrelevant to our understanding of military officers' thinking. The study involved getting people to read stories. It did not put them on an actual or a simulated battlefield. Nor did it give them the kind of written communication that they would have on a battlefield, i.e., formally structured orders. When reading stories, it is appropriate for people to pay attention to the subjective aspects of the written presentation. In fact, literary conventions train us to attend to mood information in a story. Therefore it would be appropriate for subjects to be affected by the mood of presentation in this study, but this says nothing about how they would use this information in battle.

This argument has two flaws. First, most communication in a battle does not involve formal written orders exclusively, and therefore study of the effects of other types of communication is pertinent. Second, each of the situations was reviewed for realism by more than five CGSC instructors, and changes they suggested were incorporated. Therefore the scenarios invoke more than just the subjects' "story reading" ability; they also invoke the subjects' knowledge of and responses to battlefield situations.

Different probabilities for hypothetical versus given situations. Subjects estimated different probabilities of success for the same situation, depending on whether it was the given situation that they were to assume was true, or a hypothetical situation different in one feature from the given situation. This suggests people use a cognitive process of anchoring on their probability assessment of the given situation and then insufficiently adjusting it to accomodate the change in the situation. By this process, a consistency principal is violated: probability judgments of described situations should be the same, whether the

description be "given" or "hypothetical". This inconsistency makes it difficult for numerical probability estimates to be useful as a basis for action. The following example shows why this might matter.

Often military planning is done assuming a particular enemy course of action will be done, based on the judgment that it is their most likely move (Campbell and McKinney, 1990). A number of friendly courses of action will then be developed, and a probability of success assigned to each. Then the planners may consider the hypothesis that the enemy would take an alternative course of action. If the anchoring and adjustment heuristic that was seen in this study is used to assess our options under this revised assumption, it is possible that the estimate of our probability of success if the enemy did the alternative action would be too close to the estimate of our probability of success if they did the assumed action. If so, the ranking of the possible friendly courses of action, in order of their probabilities of success, might not be sufficiently affected by a change in our assumption about what the enemy is going to do. Thus our choice of course of action might be based on wrong probability assessments.

College students more optimistic than military officers. The main difference in probability assessments between the military officers and the college students was that on the average the college students estimated that the probability of success was higher, in all five conditions of the Helicopter problem (Figure 1). This may reflect the effort in military training to make officers aware of what could go wrong. The officers' probabilities are probably better calibrated, but we can not prove this since there is no "true answer" for the Helicopter problem. No differences were found in their relative importance judgments.

Should probabilities be used? The results show several problems with officers' use of numerical probabilities. The probabilities that different people assign to the same situation vary greatly. Subjective changes in the presentation of the situation affect the probabilities although they should not (on the Helicopter problem), and objective changes affect them in the wrong way (both problems). People seem to use different processes when assigning a probability to the given situation than to a hypothetical situation that differs in one feature. Should we respond to these problems by giving up on the use of subjective judgments of probability in military command and control, and finding alternative ways of dealing with uncertainty? Or should we try to help military officers use probabilities better?

The argument for abandoning subjective probabilities is based on widespread demonstrations that people make errors in probabilistic and statistical reasoning (see Kahneman, Slovic, and Tversky, 1982), and that experts can make satisfactory

decisions without using probabilities (e.g., Klein, 1989; Kuipers, Moskowitz, and Kasserer, 1988).

On the other hand, it is possible to improve people's use of probabilities. Several alternatives are available. Military officers could be given better training in the meaning and use of probabilities. The successful performance of medical doctors (McClish and Powell, 1989) and weather forecasters (Murphy and Winkler, 1977) shows that accurate and well calibrated probabilities are possible in some domains. Whether they are possible in military contexts, which tend to present unique rather than repetitive situations, remains to be determined. Second, the use of verbal rather than numerical probabilities has been advocated (Wallsten, Budescu, Rapoport, Zwick, and Forsyth, 1986), because their inherent vagueness matches the ambiguity people feel when judging uncertainty, but helping people communicate reliably with these would require training or aids similar to what the numerical probabilities require. A third alternative is to provide a "warm-up" before requiring probability judgments. For example, a fifteen minute reminder about the meaning and use of probabilities can lessen some of the common errors in statistical reasoning (Gebotys and Claxton-Oldfield, 1989). Finally, provision of good anchors, for example in the form of a rule of thumb for calculating the probability of success which can then be adjusted for the particular case, may allow people to produce more accurate probability estimates than if they simply select a number from the 0 to 1 probability scale. This may offer improved performance even though we have demonstrated some shortcomings of the use of the anchoring and adjustment strategy for making probability estimates.

Evaluation of global measures of relative importance. Military officers' judgments of relative importance have been used to produce general models pertinent to long term planning (Coates and McCourt, 1976; Dockery and Murray, 1987), and the scope of potential applications is vast. These applications depend on the relative importance judgments being general or global. In this study, we tested whether people use the Yes/No and Rating methods of relative importance judgment in a global or local manner when considering a particular military situation. The evidence was mixed.

The most obvious opportunity for evidence that a relative importance measure is used in a local manner was in the assessment of a factor that varied between the different occasions in which importance measurements were made. In the Objective conditions, subjects rated factors (concerning the enemy threat) that were varied over large ranges. This provides a strong opportunity for a local interpretation of relative importance to manifest itself. But no significant changes in relative importance ratings were observed. In the Subjective conditions, subjects rated factors that were varied in minor ways, i.e., over small ranges of their possible values. This provided a weak opportunity for observation of local

interpretations. Again, there were no significant changes in the relative importance of these factors. Thus, there was no sign that people use these relative importance measures in a local manner, in the most obvious places for such a sign to occur. This suggests that people are interpreting the measures in a global manner, which is desirable when one is making general models.

But the study provided another opportunity for evidence of a local interpretation of the relative importance measures. It is possible for the relative importance of a factor to change in response to a change in the general expectation of success, when the particular factor has not itself been changed. Such a halo effect was observed in both problems: as the probability of success was objectively increased, those factors that are seen as contributing to success were judged as more important, and those factors seen as contributing to failure were judged as less important (statistically significant for the River problem but not for the Helicopter problem). This result suggests that subjects are using the relative importance measures in a local manner -- the importance depends on the particular situation (here, its probability of success) rather than being stable across all situations, as a global measure of importance would be. The result contradicts the conclusion that the relative importance measures are used in a global manner, which was reached above on the basis of the lack of change in the importance of the directly manipulated factors. Explaining this contradiction is a matter for further research, and it suggests that researchers should be cautious about using relative importance judgments to make general models unless they have taken steps to assure that the judgments are indeed global.

Local measure of relative importance. A local measure of relative importance could be useful. For example, in the command and control of military forces, one might need to be able to say very clearly what is important here, and it would not matter whether a factor would be important in other situations. In this view, a global expression of relative importance would be useful in a particular situation only as a rule of thumb if one must act before one has a complete understanding of the situation. The Probability Change measure of relative importance is explicitly local in character. Further, if we do not take the absolute value of the change in probability, then it offers information about direction as well as extent. In this way, probability change is a way of expressing "impact", one of Goldstein's (in press) possible forms of a local relative importance measure.[13]

To determine whether the Probability Change measure of relative importance has this local character, we investigated whether it changed in response to changes in the situation. We expected it

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13. If we needed to make probability change judgments more globally useful, we could, in addition to taking the absolute value of the change in probability of success induced by a change in the situation, consider changes from a variety of starting points or "original situations", and establish standard sizes for hypothetical changes by reference to underlying variability.

to do so more under Objective than Subjective changes in the situation. There were opposite results for the River and Helicopter problems. On the River problem, the local relative importance measure responded to Objective, but not Subjective, changes. On the Helicopter problem, it was sensitive to the Subjective but not the Objective changes. This fits with other results we have found with the Helicopter problem (discussed above).

The Probability Change method may allow for more accurate probability judgments because it uses probability change, rather than stand-alone judgments of probability. While people's assessments of the probability that something is going to happen may vary widely, they may be more accurate in their assessment of how that probability will change if an aspect of the situation changes. This may be true even though judgments of probability change are not perfect because of the involvement of the anchoring and adjustment process, as demonstrated above.

The reader might be disturbed by the apparent contradiction between the conclusion that people's probability judgments are flawed (insensitive to important variables; sensitive to unimportant variables; and different when assessing actual and hypothetical situations) and the recommendation that the Probability Change method (which depends on probability judgments) is useful as a local relative importance measure. One should keep in mind that the importance judgments probably have similar flaws to the probability judgments, only we have no way of discovering these flaws because there are no standards to which relative importance judgments can be compared. The laws of probability provide a way of providing corrective feedback for training probability change judgments, and there is no corresponding corrective for the general judgments of relative importance.

Success factors judged more important than failure factors. A final concern is why subjects judged the failure related factors to be less important than the success related factors. This might be due to arbitrary choices made in the construction of the problems: the failure related factors happened to be ones that people think are less important. Or it may reflect people's tendency to think in terms of producing success, rather than in terms of avoiding failure. This is a problem for future research. It would be easy to control for variation in the size of the success and failure factors through a device such as assigning different subjects to different sides of the same situation.

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Please read the following problem. You will be asked to evaluate the commander's plan by estimating its probability of success and suggesting improvements. You will also be asked to rate the importance of different factors facing the commander.

Downed Helicopter Problem

Captain Smith is a rifle company commander in a U.S. campaign to assist a third world government fighting against well armed insurgent forces. His company has responsibility for an area of operations on the western edge of a valley that runs north and south [see map on next page]. The international border is several kilometers farther east. The enemy's bases are on the other side of the border, and for political reasons no major offensive has been launched against them. The enemy is frequently active on the eastern edge of the valley, separated from Smith's company by a 4000 meter area that is difficult to move through due to swamps, streams and ravines, dense jungle, and no roads. **There has been little enemy activity in this sector, other than probes and occasional contacts, over the last several days.** [*]

Intelligence does not think that an attack is imminent, but warns that the company should be alert for reconnaissance patrols and probes.

It is a half hour after dawn. Weather has been heavily overcast for two days, and this morning's **thick fog** is expected to stay on or near the ground, **with intermittent light rain,** all day. A few minutes ago a helicopter was heard in the valley, approaching from the south. Although it came close, it was not visible due to the fog. None of Capt. Smith's people could identify its type from the sound. Observers heard the helicopter crash approximately 2000 meters in front of the forward observation post, about midway through the valley.

A call to headquarters produced no information about the identity of the helicopter. Smith was ordered to "Check it out. It might be one of ours, and if so they are probably going to need some help. The Assistant High Minister of Defense was scheduled to inspect the area north of us today. Maybe he got lost. If it is the enemy's, we might get important information from the survivors or the wreckage." [*]

Capt. Smith tells Lt. Wilson, one of his platoon leaders, to send a squad to find the helicopter, aid the injured, protect them and bring them back if they are ours, and to get prisoners and information if they are the enemy. **Capt. Smith notices that Lt. Wilson is eager to lead the**

patrol himself, but Wilson decides to send a ten-man squad under Sgt. Jones, who has much more experience moving about in the area. Jones has led 20% of the patrols in this area since the company took up its position, and has debriefed most of the other patrols. Because of the urgency of the situation (probable injuries, and the possibility that the enemy will get there first), Capt. Smith instructs Wilson that the patrol should take the most direct route to the likely crash site. [*]
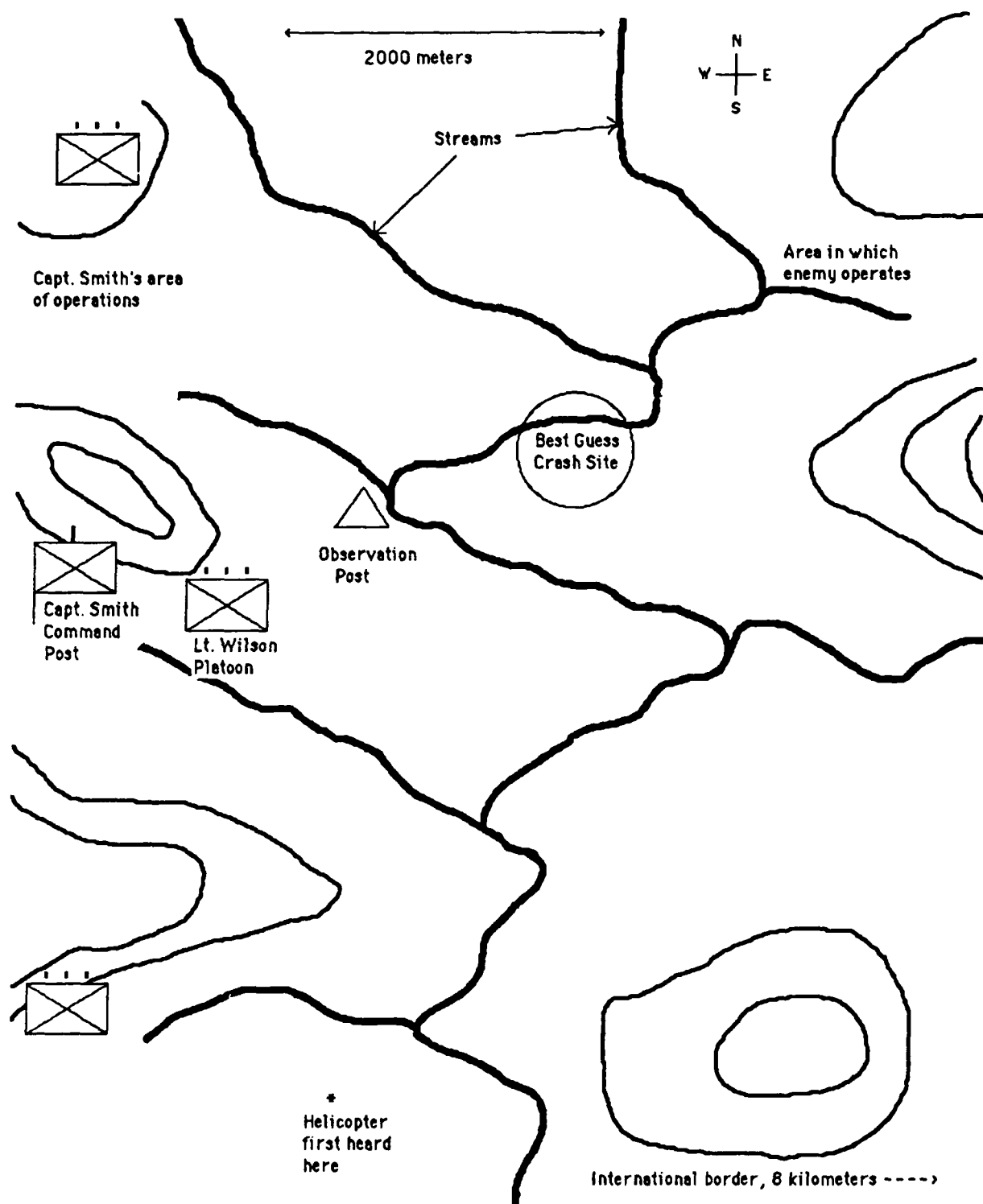
2000 meters

N
W — E
S

Streams

Capt. Smith's area
of operations

Area in which
enemy operates

Best Guess
Crash Site

Observation
Post

Capt. Smith
Command
Post

Lt. Wilson
Platoon

Helicopter
first heard
here

International border, 8 kilometers ----->

Figure A-1.

Please read the following problem. You will be asked to evaluate the commander's plan by estimating its probability of success and suggesting improvements. You will also be asked to rate the importance of different factors facing the commander.

River Crossing Problem

Lieutenant Colonel Rubel commands a mechanized infantry battalion that is located in the front line. The battalion moved into its current position unopposed in the early evening. It is 2300, and LTC Rubel is finalizing his plans for the next day's battle. [*] The enemy is across a small river [see map on next page], in several small wooded hills a kilometer back from the river. They too have just arrived in their positions within the past **several hours.**

LTC Rubel's orders are to establish a bridgehead on the other side of the river by destroying or driving off the enemy forces and taking the hill marked 434, and clearing the objective of enemy. The attack is to start by 0700, and Rubel is to take Objective Tiger (Hill 434) and clear the area by 1200, and prepare a hasty defense. The purpose is to allow a larger force to ford the river here and attack to the northwest.

Since the arrival of the order, LTC Rubel's staff has presented him with the following information.

River crossings. Scouts report the river is easily fordable at points X, Y, and Z, with low firm banks and a firm bottom.

Weather. No rain is expected for 24 hours. Wind will be light, from the southwest, and so smoke can be used.

Terrain. Hill 434 though high is fairly accessible. There are no cliffs, and the wooded slopes are not so steep that people will have trouble climbing them, although due to the trees and the slope, it is not anticipated that vehicles can be used in the assault on the hill. The area between the river and the bottom of Hill 434 is lightly wooded with numerous old logging trails. Cross-country mobility is poor. On the east and west shoulders of Hill 434, the ground rises gently to the ridge line. There are somewhat steeper slopes in the middle of the hill. The upper part of the hill approaches a 40 degree slope, with a minimal number of rocky outcroppings.

Enemy forces. Intelligence reports that the enemy is a motorized rifle battalion equipped with BTRs (wheeled armored personnel carriers), with 3 companies, two at the front and one in reserve [placed approximately as shown on the map], and they **have been attrited to 70% strength.** After retreating into the area following today's battles to the east, the enemy has started preparing defensive positions. **They are not likely to attack here tonight or tomorrow.** It can be assumed that there are at present no mines in the river valley, since the enemy has not had time to place any, and friendly forces have not left any there earlier.

The three hills provide the enemy with good observation, and **they will be able to bring fire** from both mortar and artillery to bear on the attack. The battalion will have support from the regiment's organic artillery battalion, and it is likely they will have additional artillery support. It is assumed that the enemy has no helicopter or air support available for use in this sector, due to losses in previous weeks and because their air resources are being concentrated for a major battle being fought to the north and east.

Friendly forces. Rubel's task force (three rifle companies and one cross attached tank company) are at 85% strength. Each of the mechanized rifle companies has 10 M2 Bradley fighting vehicles. The tank company has 11 M1 tanks. Only light wind is expected, and so it will be possible to generate smoke to limit visibility during the river crossings. Smoke is available from the 6 mortars of the headquarters company, from the two batteries of 155's that have been made available to the battalion during the morning hours, and from smoke generators that have been provided. Unfortunately, no helicopter or air support is available. A scout platoon is forward for screening and reconnaissance. They report some enemy activity in the plain between Hill 434 and the river.

Rubel's plan is to slow the enemy's preparations with harassing and interdicting artillery fire and occasional mortar fire throughout the night. **This should make it more difficult for them** to place obstacles in the fords or mine the approaches to Hill 434, as well as slowing their defensive preparations. The tank company (Blue Company C) and Company B will take positions on Hills 340 and 312, from which they will be able to apply overwatching direct suppressive fire during the first phase of the attack.

At 0500, the scouts will cross the river (under smoke) and deploy in the plain, seek to discover enemy positions, check the route that the armored personnel carriers will use later, and take up positions to protect the flanks of the coming attack. Then while Companies B and C supply suppressive fire and the artillery smokes the enemy on Hill 434 to prevent their observations, **Companies A and D will cross ford X** under smoke and move as rapidly as possible to attack the western half of the hill. As they cross Phase Line CAT, the artillery will shift target to the top and the eastern half **of Hill 434, to prevent** the forces there from firing on the two companies. The tank company (C) will continue to provide direct suppressing fire to the western half of the hill, while Company B will prepare to ford the river.

While Companies A and D attack the western half of the Hill 434, Company B will ford the river and move into position to either support them or attack the eastern half of the hill. **The artillery will shift to suppressing** the rear enemy forces on Hills 230 and 318. When Companies A, B, and D are consolidating on the objective, the tank company will move down from Hill 312 and prepare to ford and protect Hill 434 from counterattack.
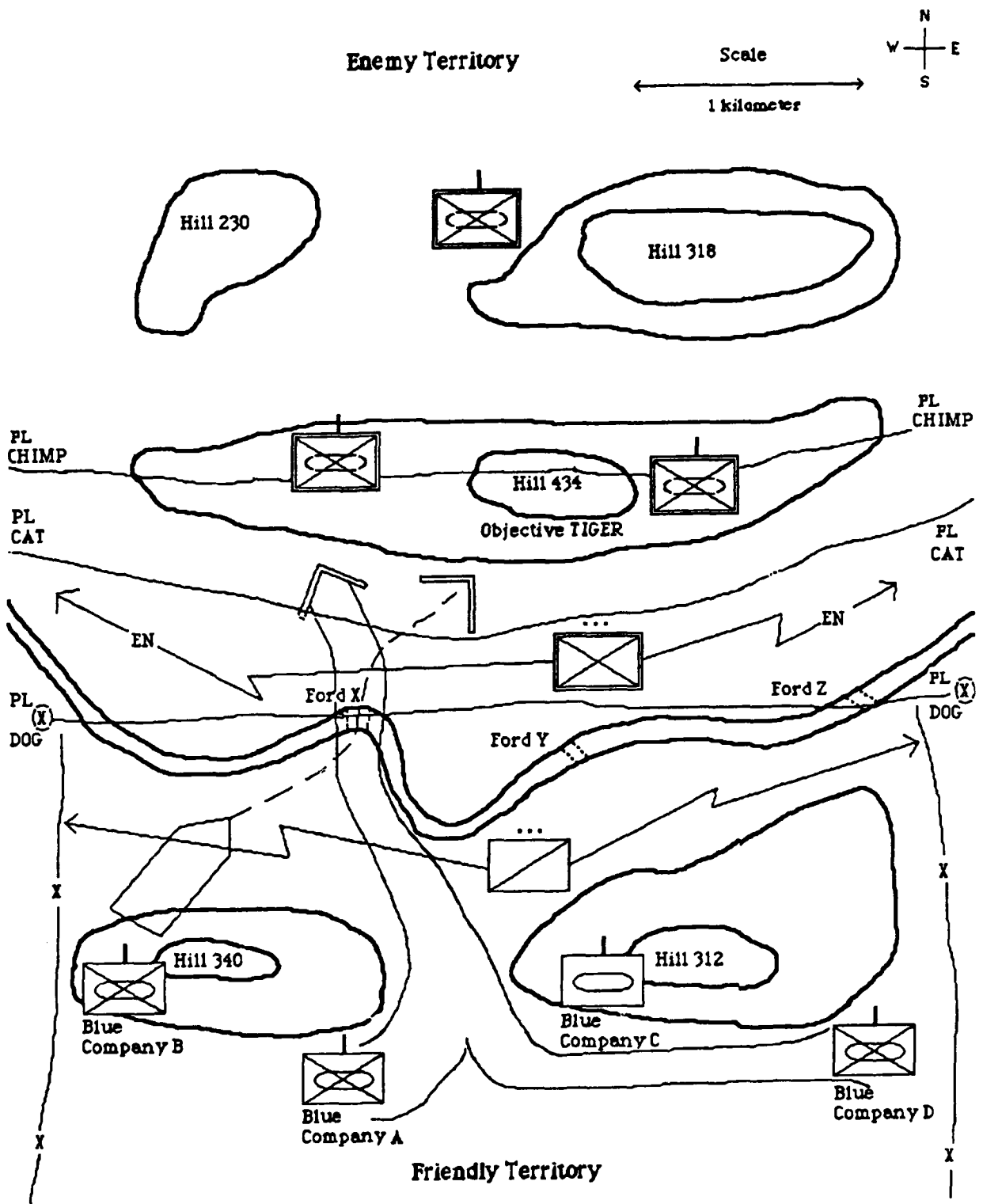
[*]

Figure A-2.

Appendix C.
Probability Change questions for Helicopter Problem.

Probability Change Importance Rating.
The success of Capt. Smith's plan depends on several important factors. Please consider the following list, and estimate what the probability of mission success would be if the factor were to change as described. Please give specific probabilities. Each of the changes should be considered independently, leaving all other features as described originally.
Refer to the "Plan Evaluation" question above to review your estimate of the probability that the patrol will succeed in finding the helicopter and returning with the injured or prisoners, given current conditions and Capt. Smith's original plan.

What would be the probability of mission success if the fog were to lift so that both Sgt. Jones' patrol, and the enemy, had good visibility?
_____

What would be the probability of mission success if the enemy were able to see where the helicopter crashed and has already sent two patrols? _____

What would be the probability of mission success if the actual crash site were more than 1000 meters from the estimated crash site?
_____

What would be the probability of mission success if Lt. Wilson had led the patrol himself instead of assigning Sgt. Jones who has more experience with the terrain? _____

What would be the probability of mission success if Captain Smith had ordered the patrol to take a safe but slow, indirect route instead of the most direct route to the estimated crash site? _____

What would be the probability of mission success if Captain Smith had sent two separate patrols rather than just one? _____

What would be the probability of mission success if Captain Smith had sent a large patrol (30 men rather than 11)? _____

What would be the probability of mission success if Captain Smith had decided to request aerial reconnaissance before sending out the patrol? _____

Appendix D.
Probability Change questions for River Problem.

Probability Change Importance Rating.

The outcome of LTC Rubel's attack plan depends on several important factors. Please consider the following list, and estimate what the probability of attack success would be if the factor were to change as described. Please give specific probabilities. Each of the changes should be considered independently, leaving all other features as described originally.

Refer to the "Plan Evaluation" question above to review your estimate of the probability that the attack will succeed in taking Hill 434 by 1200 given current conditions and LTC Rubel's original plan.

What would be the probability of attack success if the enemy in fact were at 70% strength? _____

What would be the probability of attack success if the brigade were not able to provide the battalion with field artillery support during the attack? _____

What would be the probability of attack success if the river could not in fact be forded by the M2s? _____

What would be the probability of attack success if the roads in the area between the river and Hill 434 were mined and blocked?

_____

What would be the probability of attack success if the enemy turned out to have completed preparing its defensive positions on Hill 434? _____

What would be the probability of attack success if the enemy turned out to have positions in the area between the river and Hill 434? _____

What would be the probability of attack success if it were possible for LTC Rubel to be supported by five attack helicopters? _____

What would be the probability of attack success if the enemy were to have fighter and attack helicopter support? _____